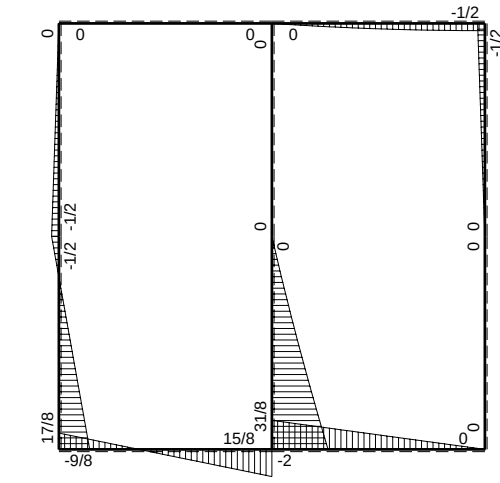
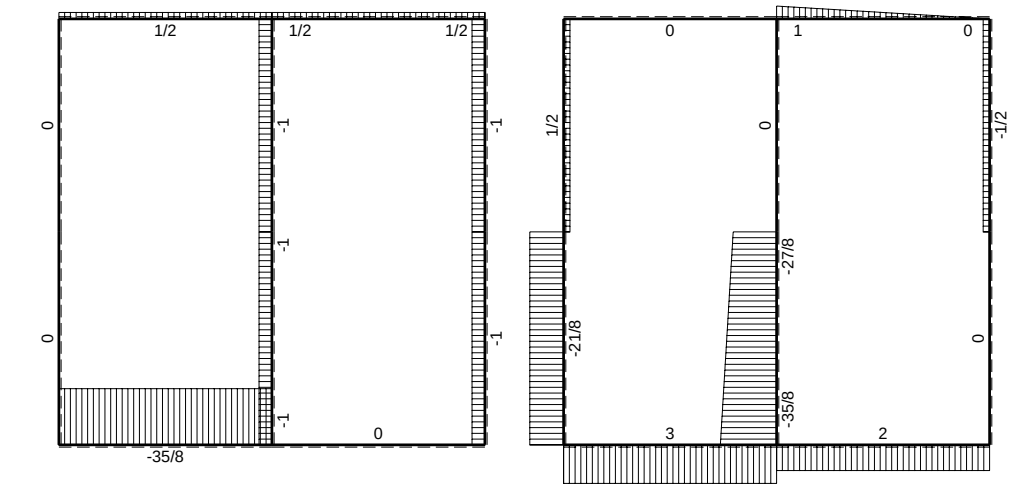
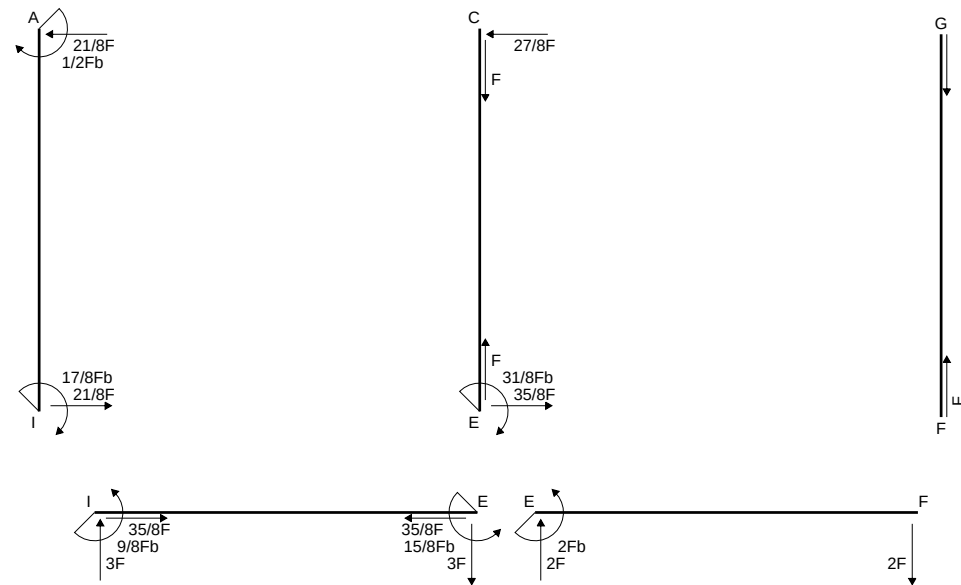
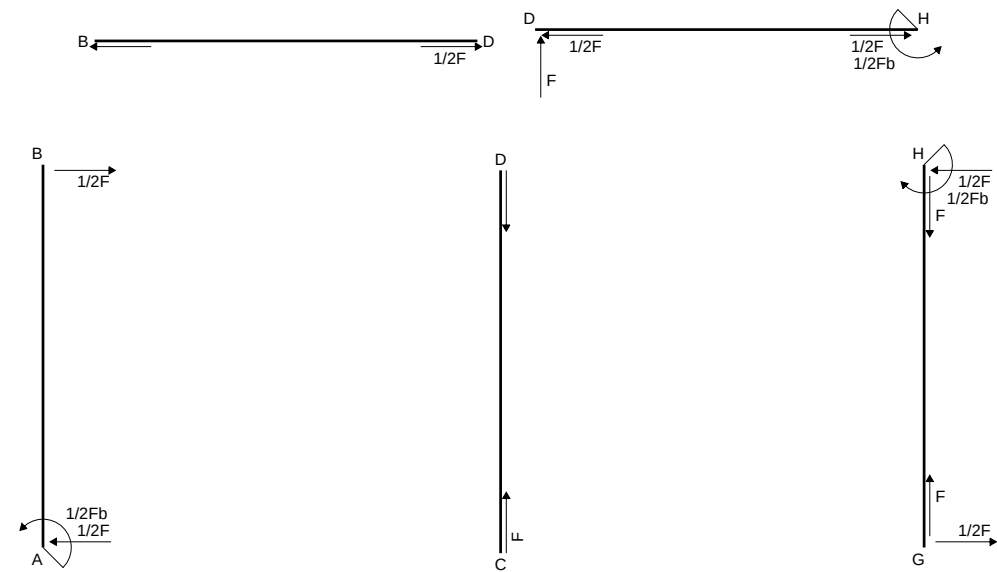


Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-11/2Fx+1/2qx^2$	0	$-5Fb+21/2Fx-6Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-13/8+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx-1/2qx^2$	0	$-9/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-15/8Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 6x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-5x + 21/4 x^2/b - 2x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 21/4 b - 2b + 1/8 b) Fb \frac{1}{EJ} = -13/8 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

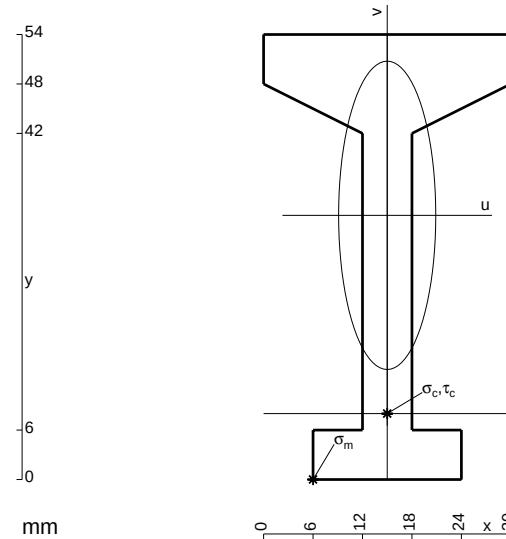
$$= (-3/2 b - 1/8 b) Fb \frac{1}{EJ} = -13/8 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 612. \text{ mm}^2$$

$$J_u = 214270. \text{ mm}^4$$

$$J_v = 21276. \text{ mm}^4$$

$$y_g = 32.06 \text{ mm}$$

$$T_y = 2360. \text{ N}$$

$$M_x = -1392400. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -32.06 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.3 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 8. \text{ mm}$$

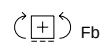
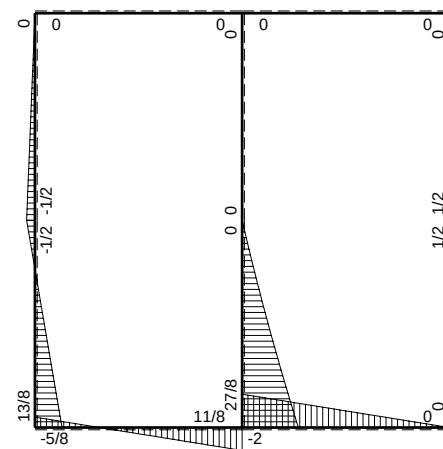
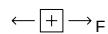
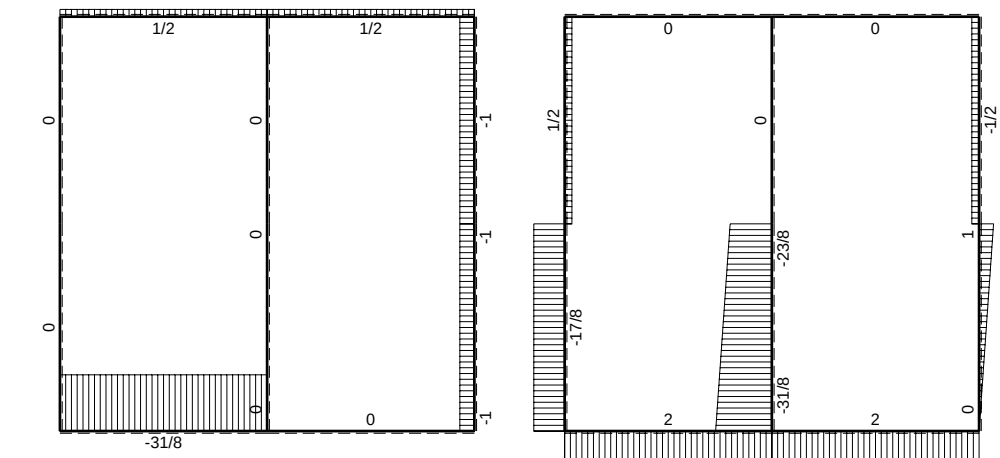
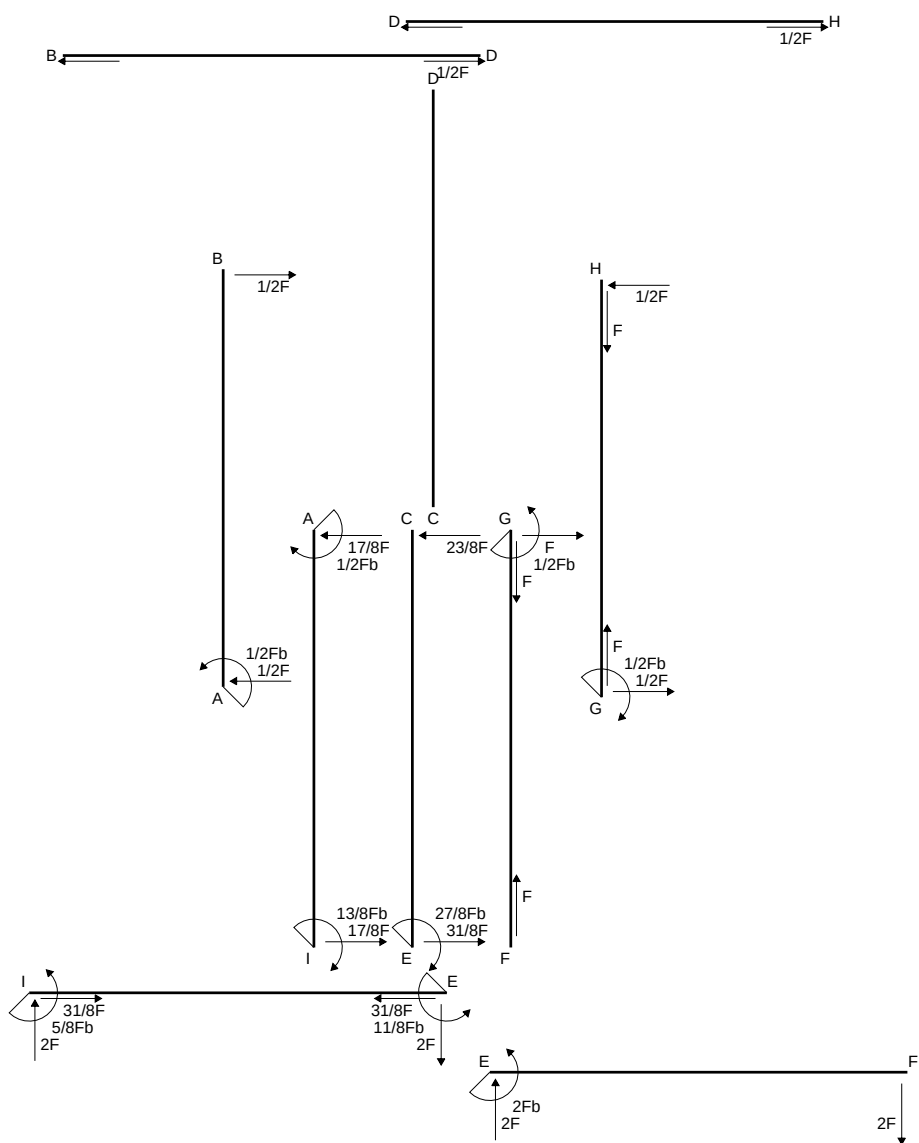
$$v_c = -24.06 \text{ mm}$$

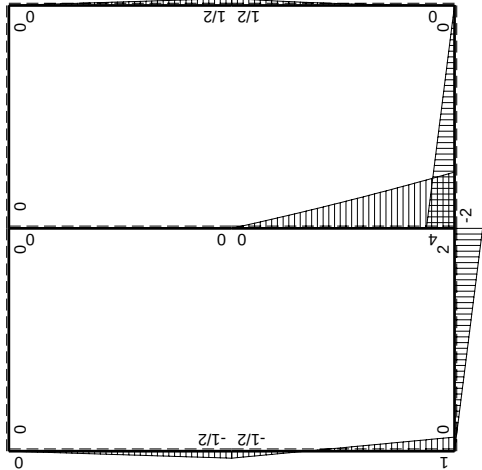
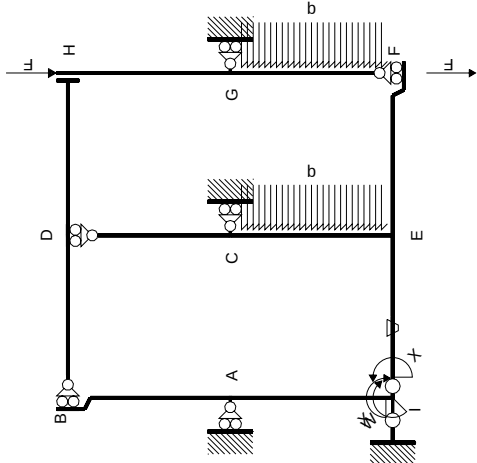
$$\sigma_c = -Mv/J_u = -156.3 \text{ N/mm}^2$$

$$\tau_c = 6.313 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 156.7 \text{ N/mm}^2$$

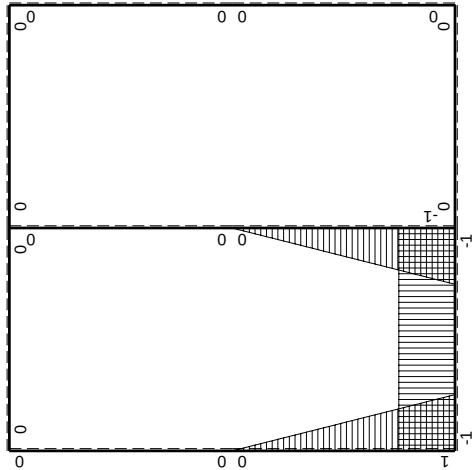
$$S = 3439. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= \left[-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-7/6 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

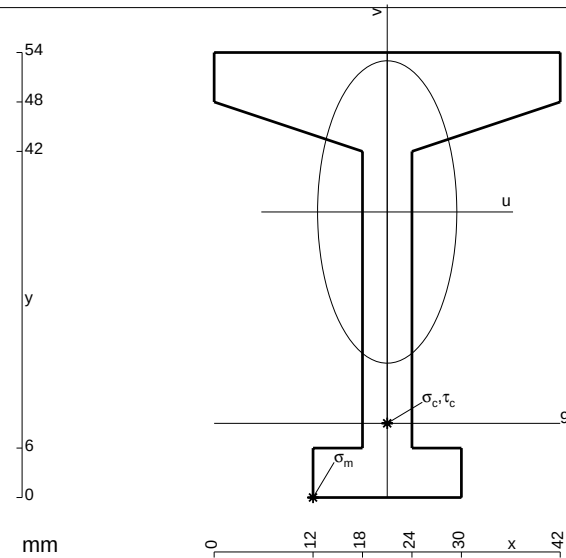
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 720. \text{ mm}^2$$

$$J_u = 242552. \text{ mm}^4$$

$$J_v = 51408. \text{ mm}^4$$

$$y_g = 34.65 \text{ mm}$$

$$T_y = 2400. \text{ N}$$

$$M_x = -1536000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.65 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

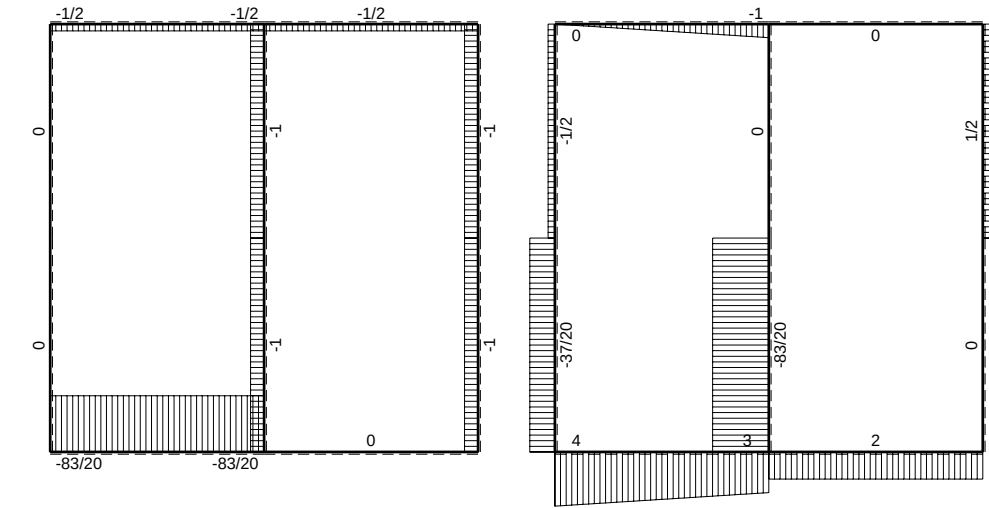
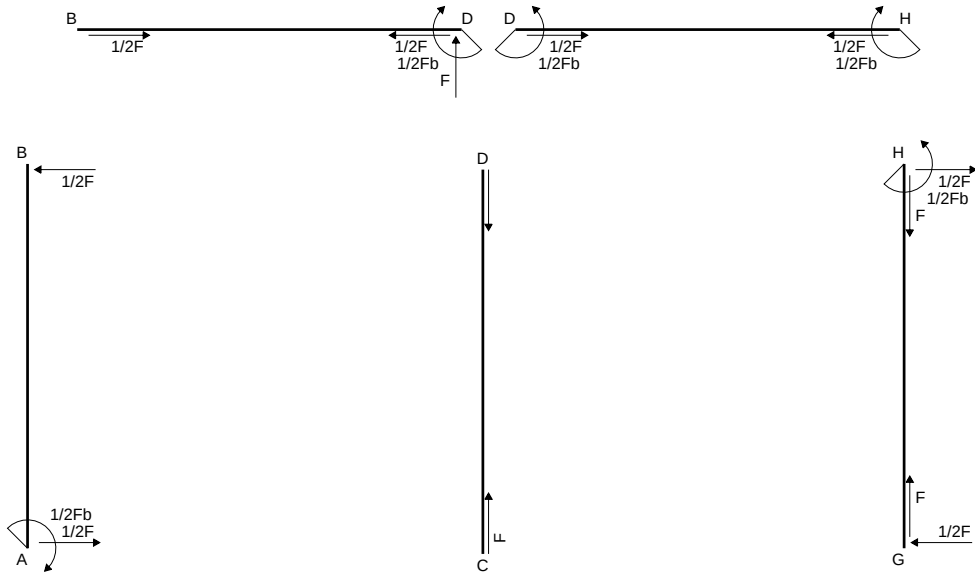
$$v_c = -25.65 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -162.4 \text{ N/mm}^2$$

$$\tau_c = 6.443 \text{ N/mm}^2$$

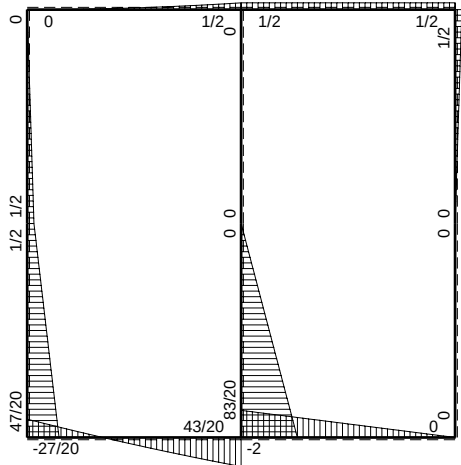
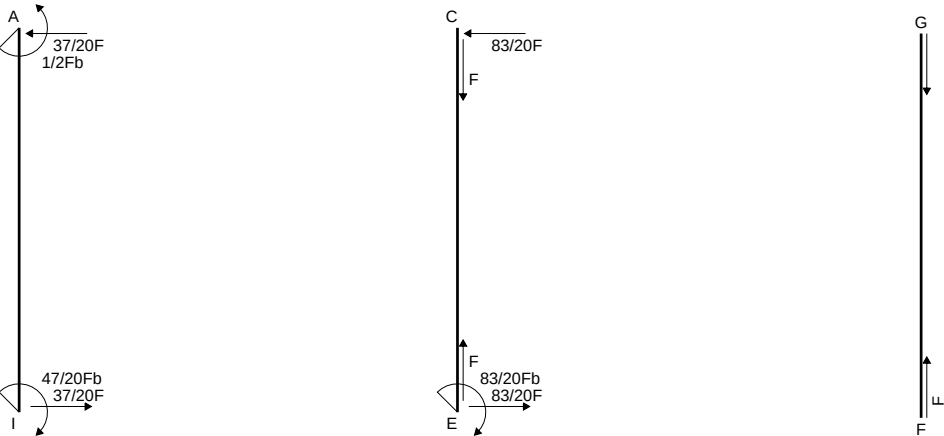
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 162.8 \text{ N/mm}^2$$

$$S = 3907. \text{ mm}^3$$

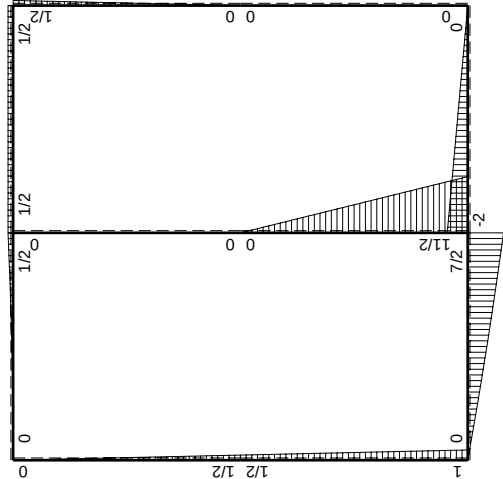
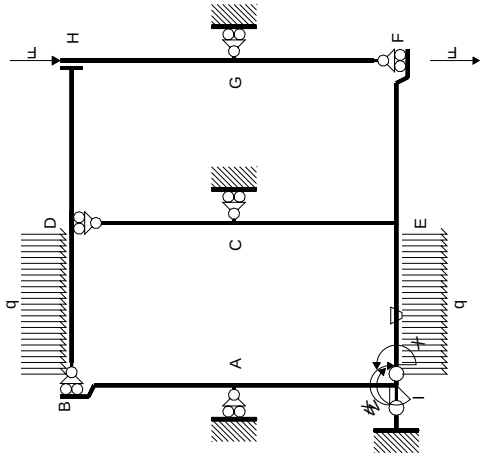


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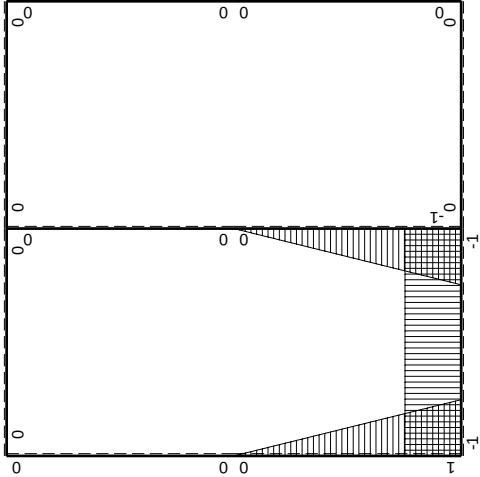


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-9/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$27/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

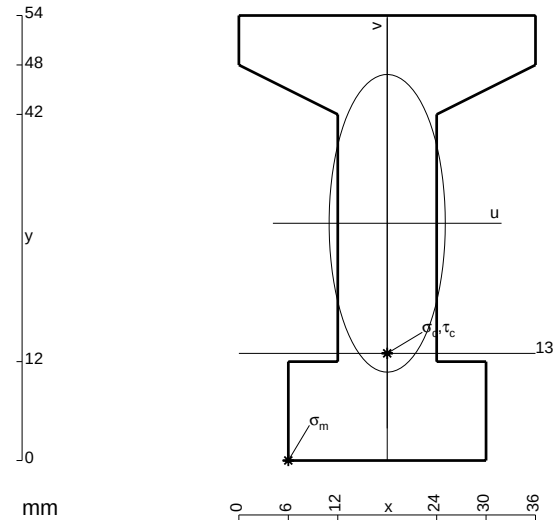
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



$$A = 1008. \text{ mm}^2$$

$$J_u = 328994. \text{ mm}^4$$

$$J_v = 50112. \text{ mm}^4$$

$$y_g = 28.79 \text{ mm}$$

$$T_y = 3740. \text{ N}$$

$$M_x = -2618000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.79 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.1 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

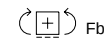
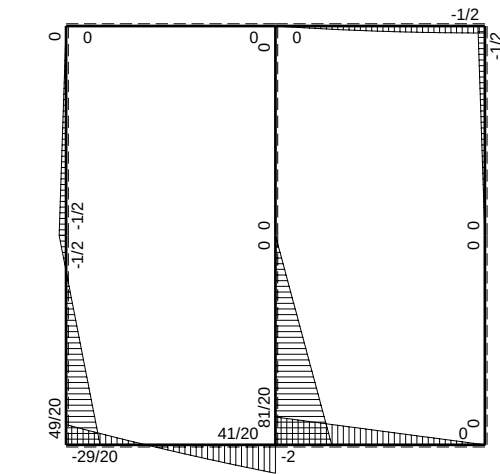
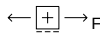
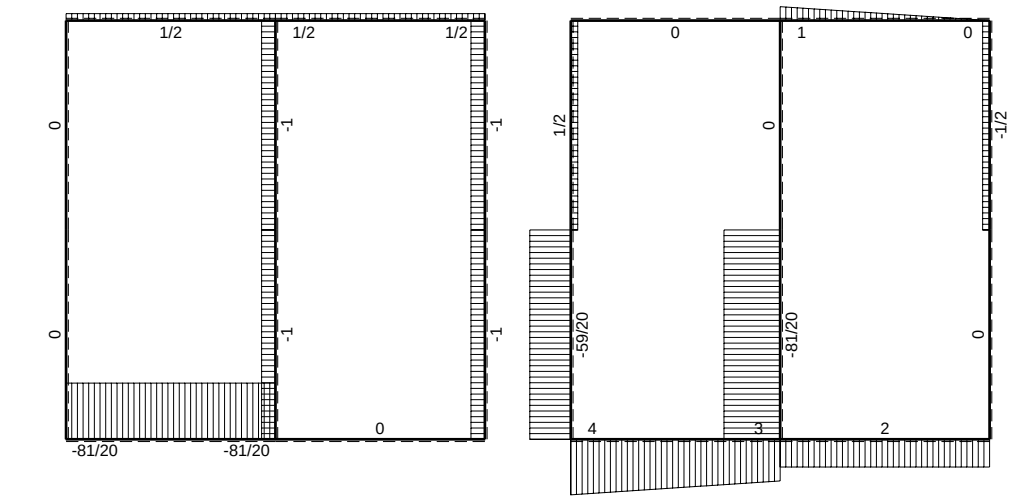
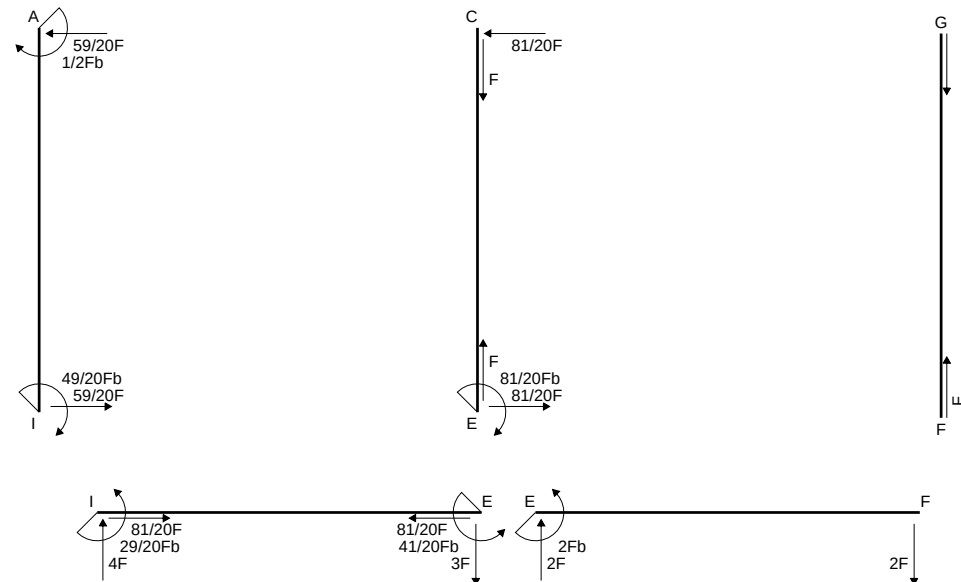
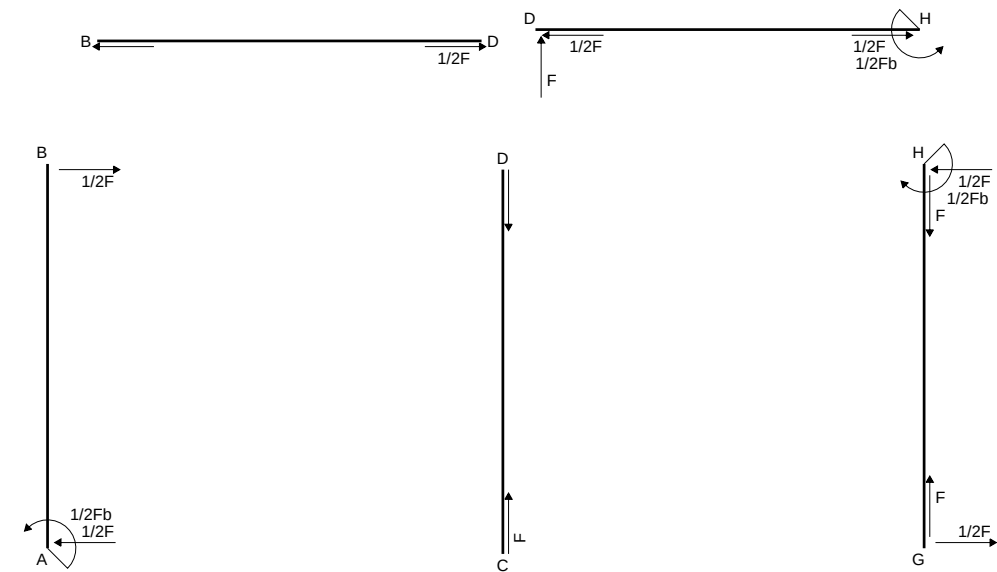
$$v_c = -15.79 \text{ mm}$$

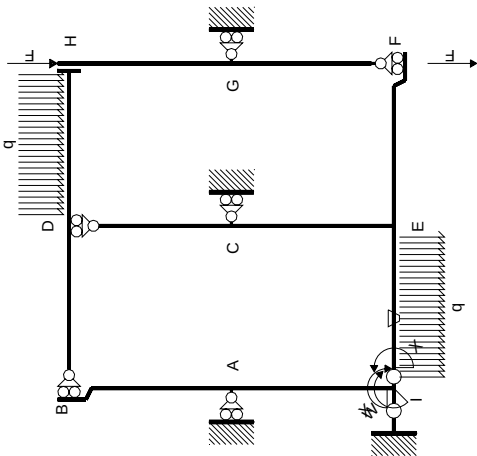
$$\sigma_c = -Mv/J_u = -125.6 \text{ N/mm}^2$$

$$\tau_c = 6.402 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 126.1 \text{ N/mm}^2$$

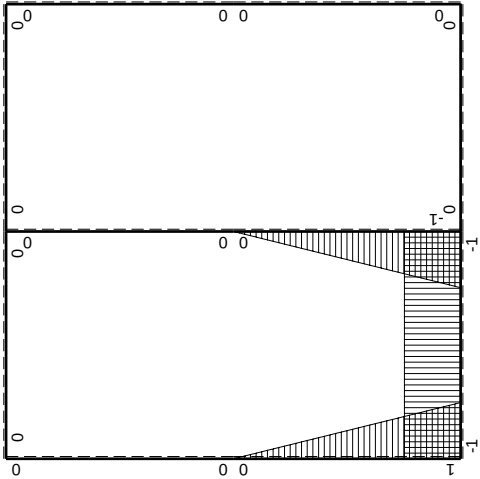
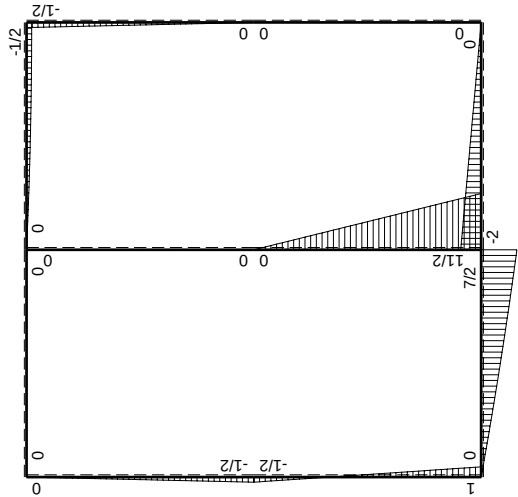
$$S = 6758. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

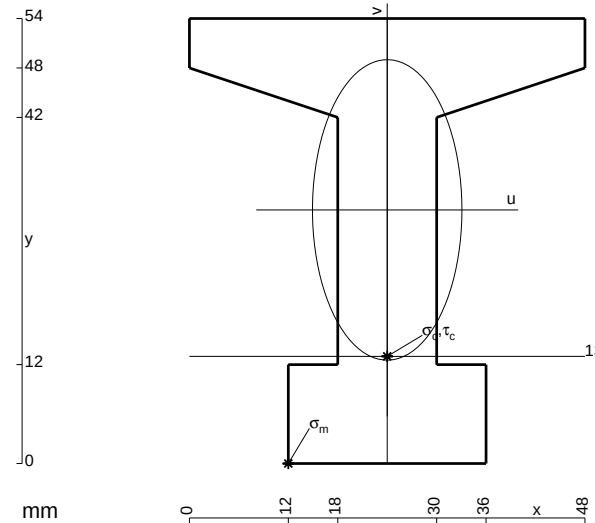
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 1116. \text{ mm}^2$$

$$J_u = 371067. \text{ mm}^4$$

$$J_v = 91800. \text{ mm}^4$$

$$y_g = 30.77 \text{ mm}$$

$$T_y = 3840. \text{ N}$$

$$M_x = -2880000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.77 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -238.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

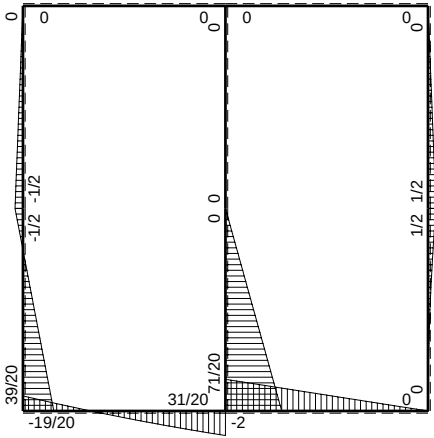
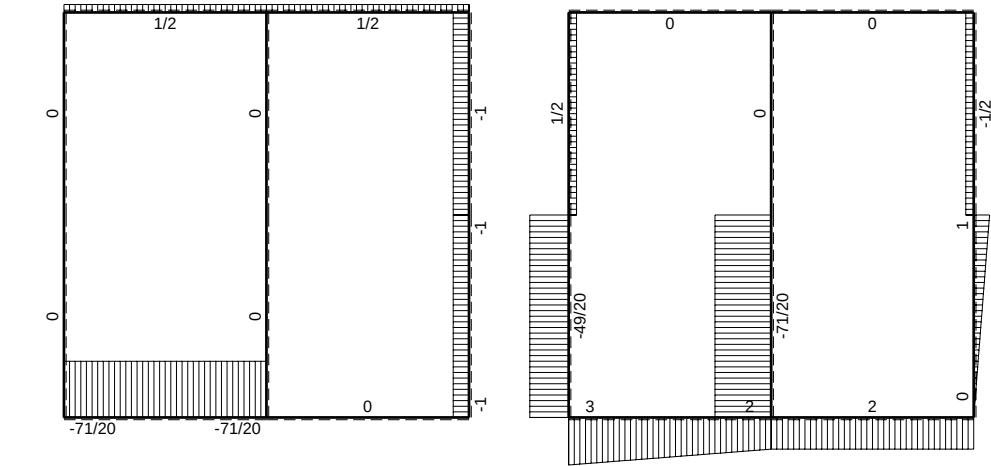
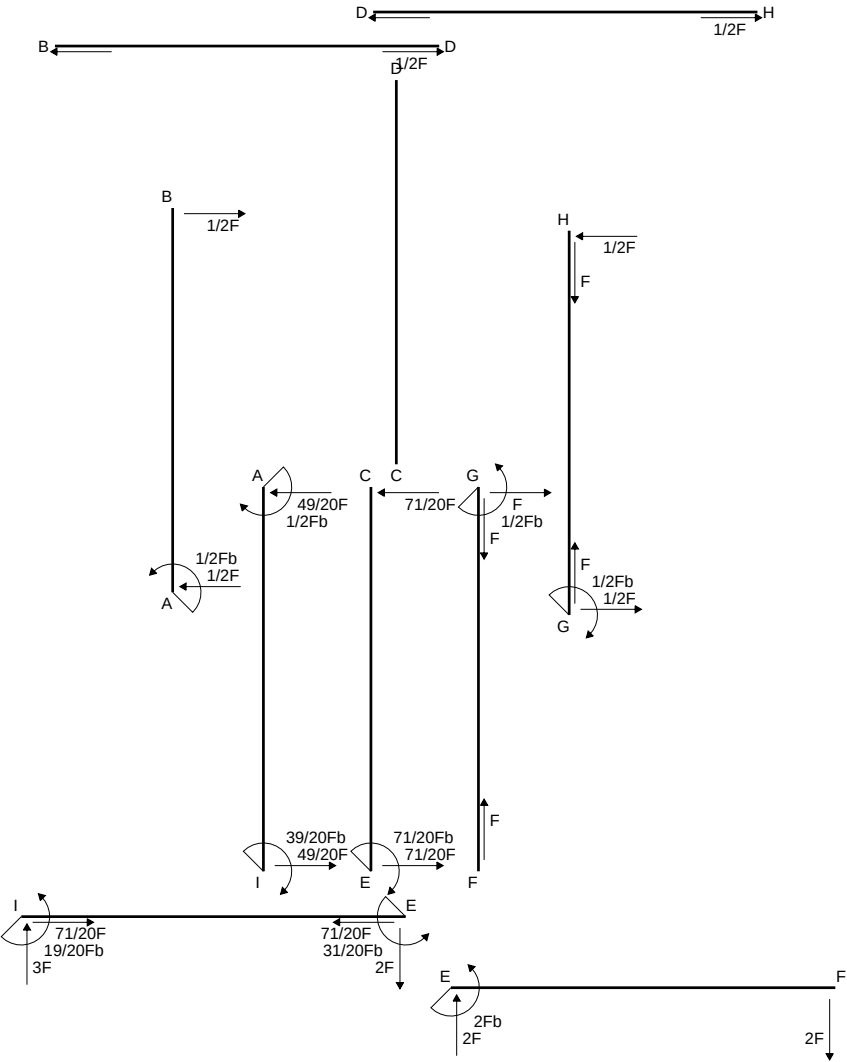
$$v_c = -17.77 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -138. \text{ N/mm}^2$$

$$\tau_c = 6.342 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 138.4 \text{ N/mm}^2$$

$$S = 7354. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-19/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

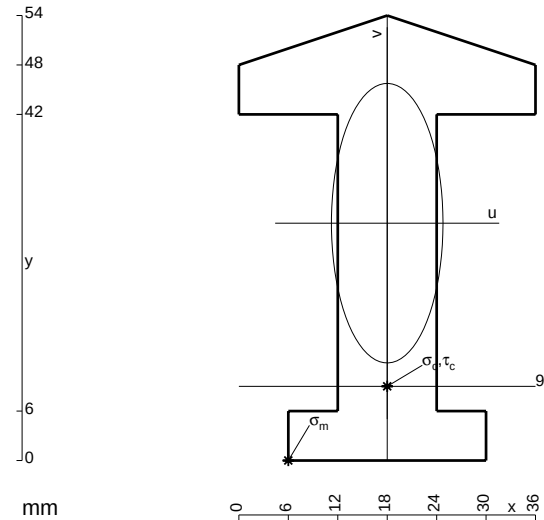
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 900. \text{ mm}^2$$

$$J_u = 258984. \text{ mm}^4$$

$$J_v = 41256. \text{ mm}^4$$

$$y_g = 28.8 \text{ mm}$$

$$T_y = 2220. \text{ N}$$

$$M_x = -1798200. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.8 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -200. \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

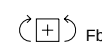
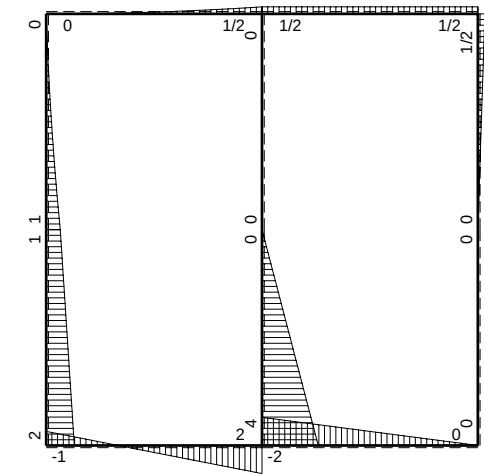
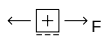
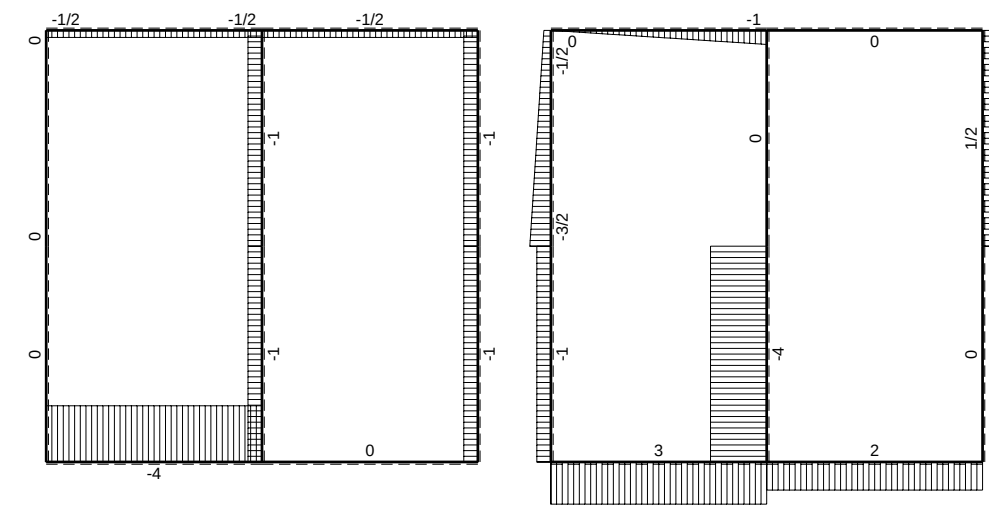
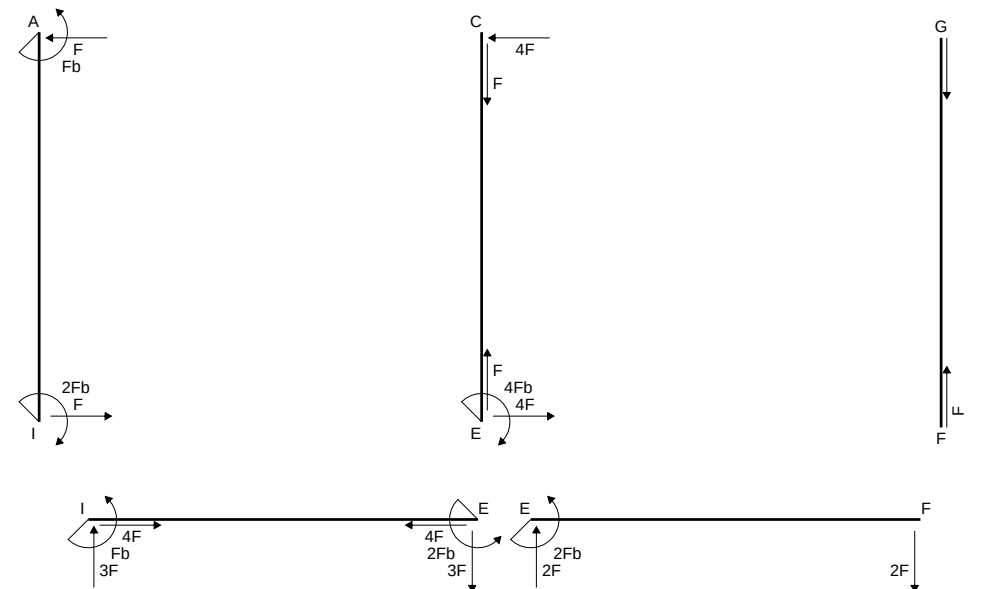
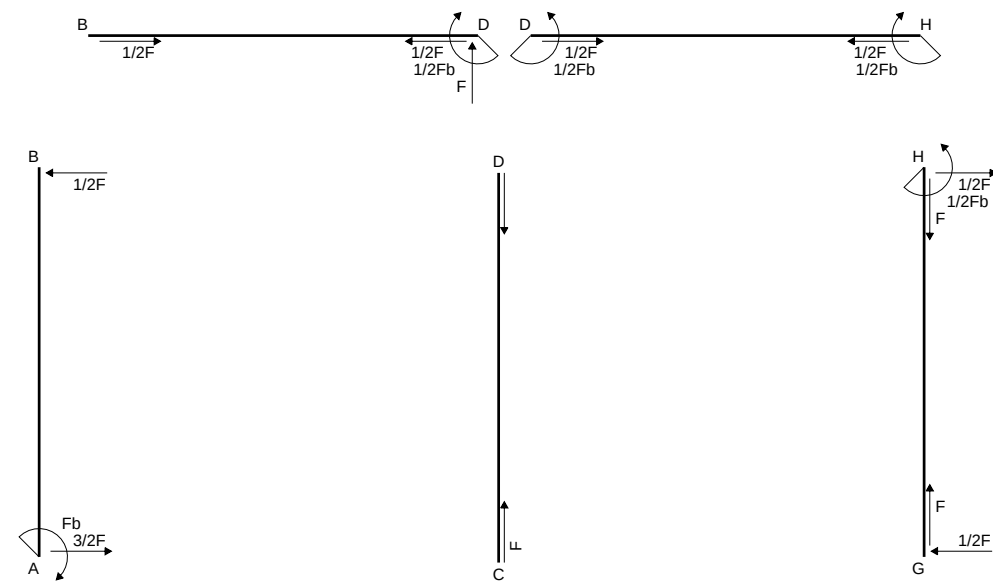
$$v_c = -19.8 \text{ mm}$$

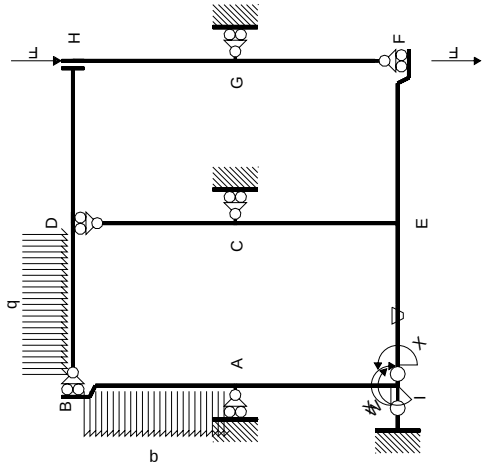
$$\sigma_c = -Mv/J_u = -137.5 \text{ N/mm}^2$$

$$\tau_c = 3.202 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 137.6 \text{ N/mm}^2$$

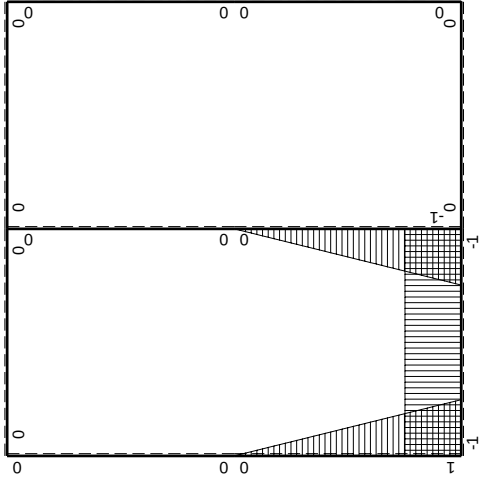
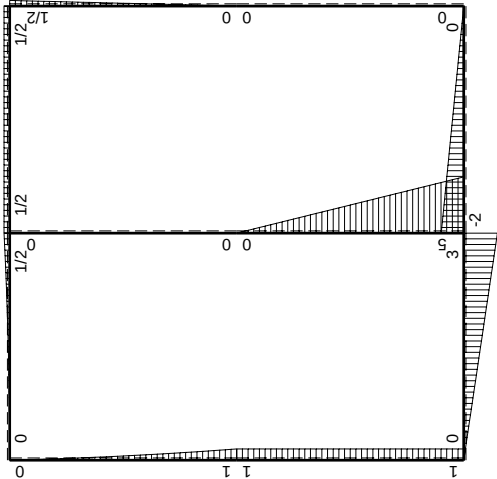
$$S = 4482. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb	0	$Fb-Fx$	0	$1-2x/b+x^2/b^2$	$(1/2+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb$	0	Fx	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

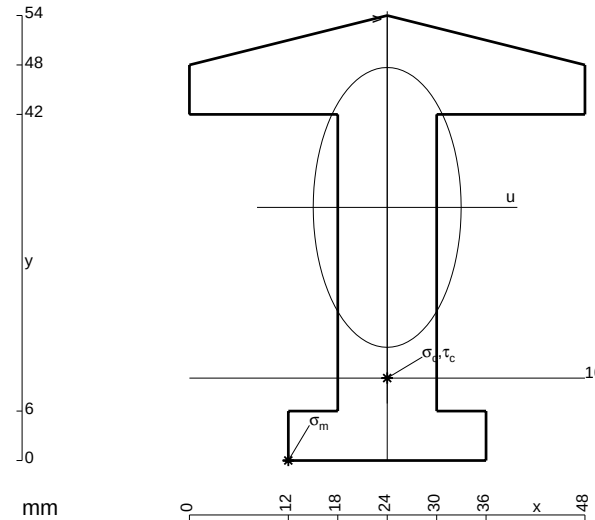
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - x/b) Fb \frac{1}{EJ} dx = \left[x - 1/2 x^2/b \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$



$$A = 1008. \text{ mm}^2$$

$$J_u = 290654. \text{ mm}^4$$

$$J_v = 81216. \text{ mm}^4$$

$$y_g = 30.71 \text{ mm}$$

$$T_y = 2300. \text{ N}$$

$$M_x = -1978000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.71 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

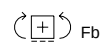
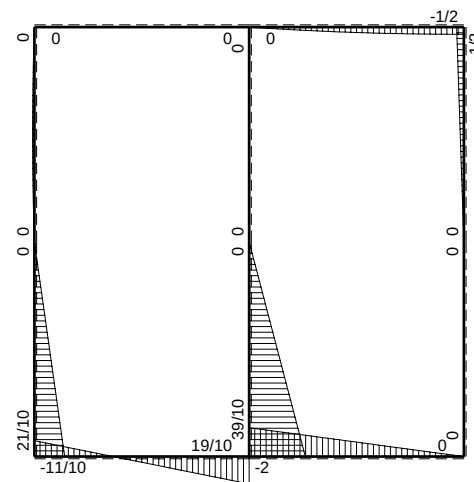
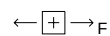
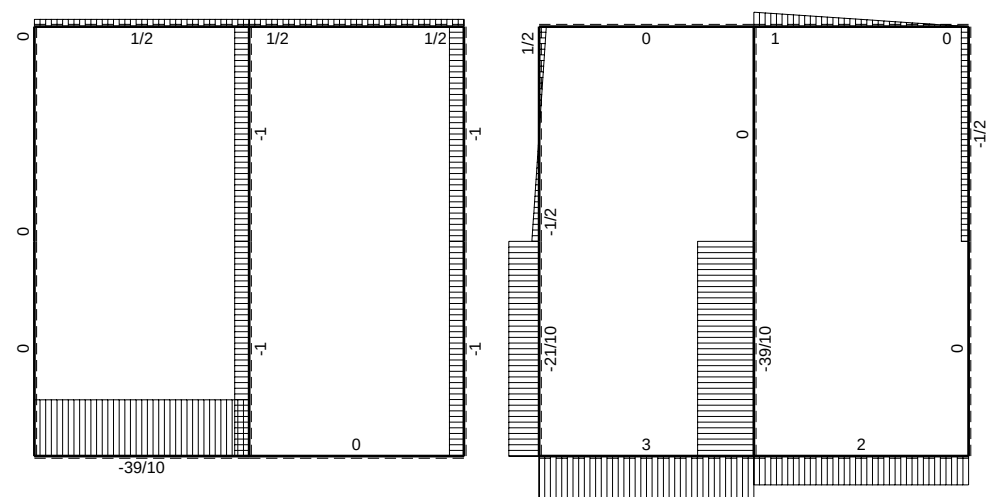
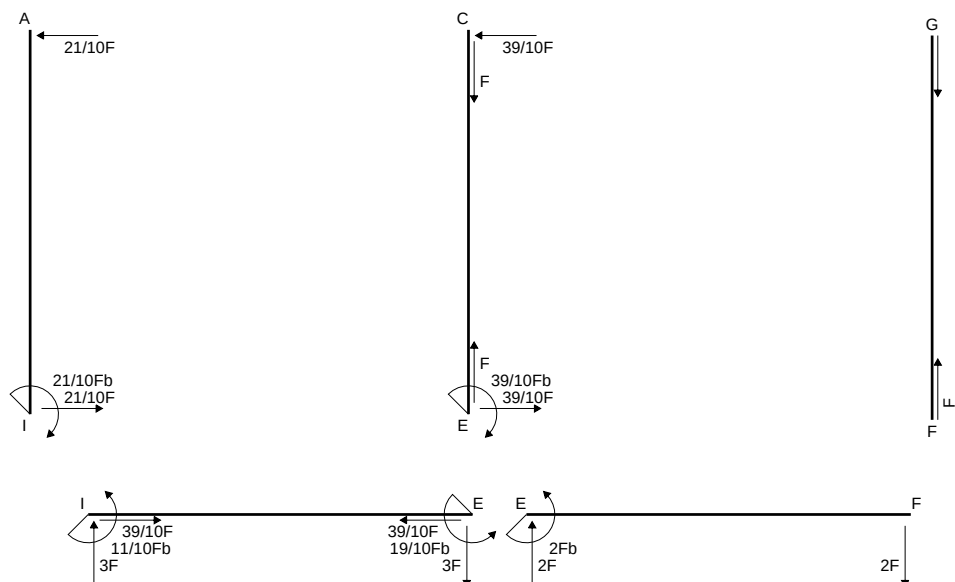
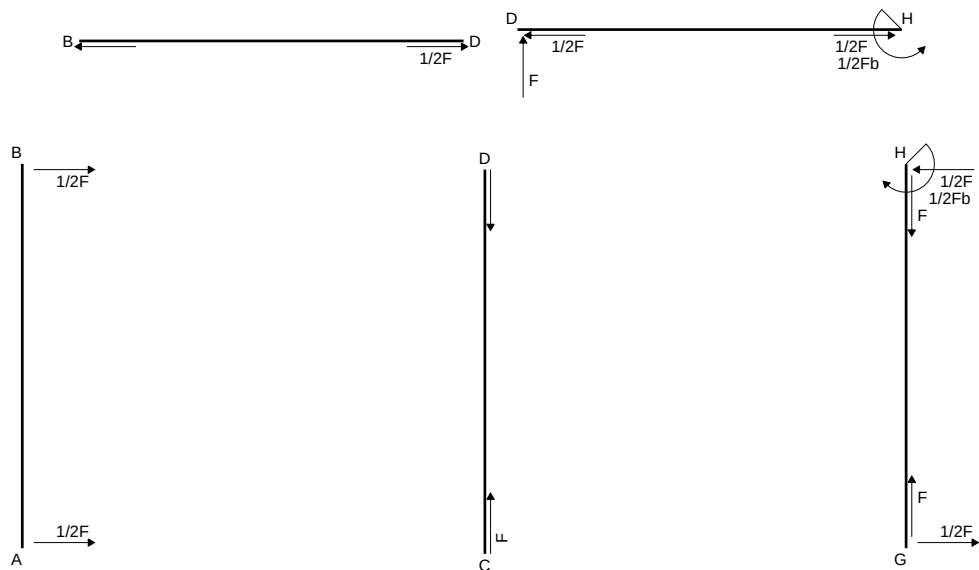
$$v_c = -20.71 \text{ mm}$$

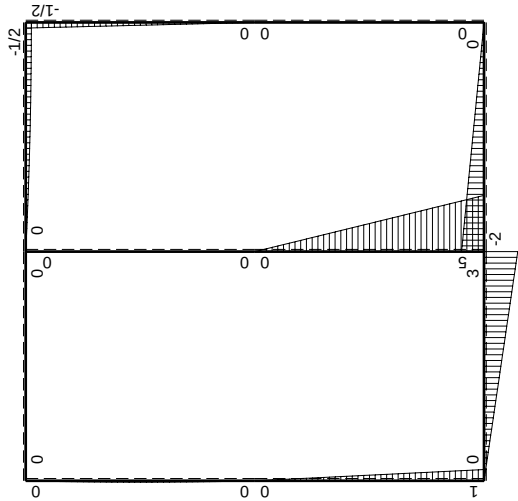
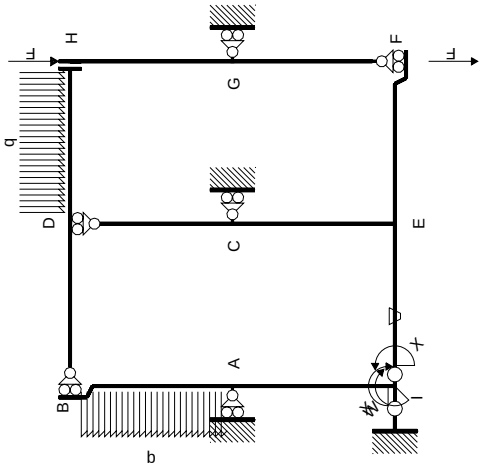
$$\sigma_c = -Mv/J_u = -141. \text{ N/mm}^2$$

$$\tau_c = 3.351 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 141.1 \text{ N/mm}^2$$

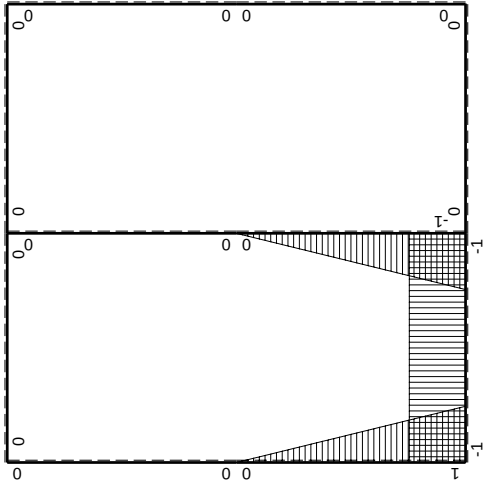
$$S = 5081. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati

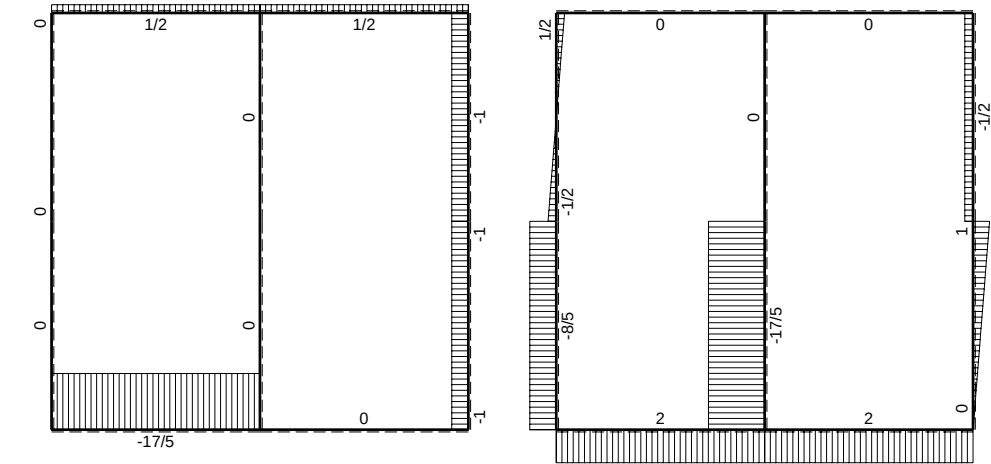
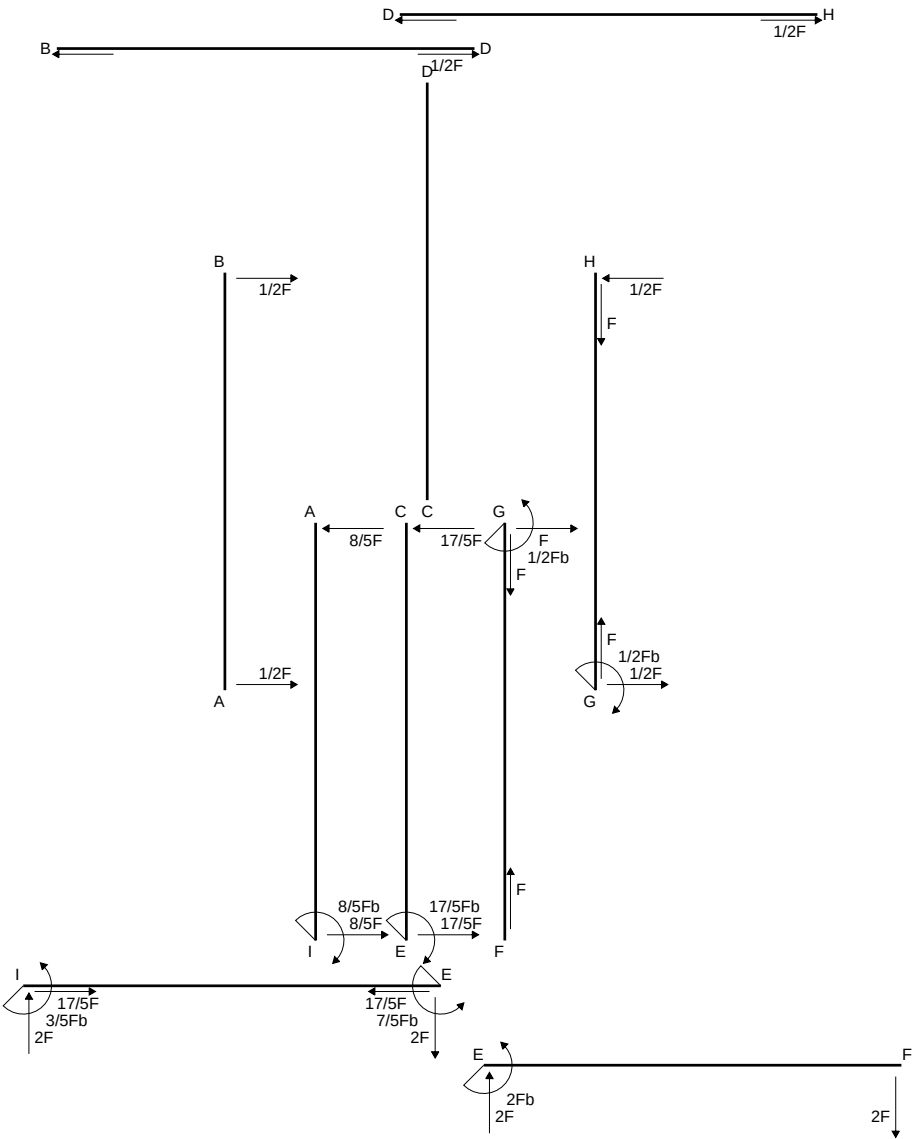


 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

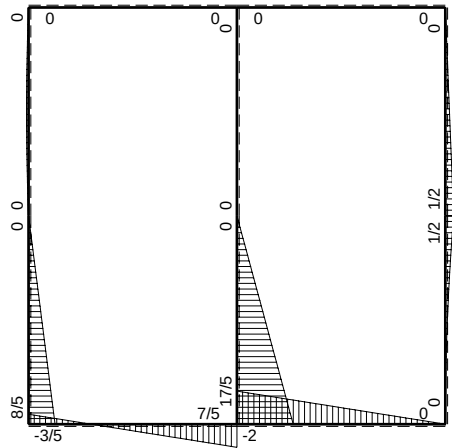
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

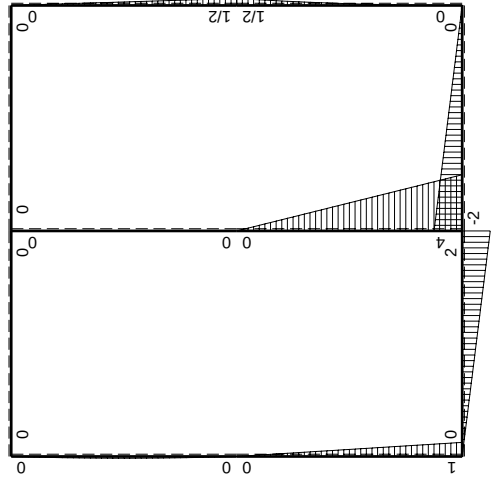
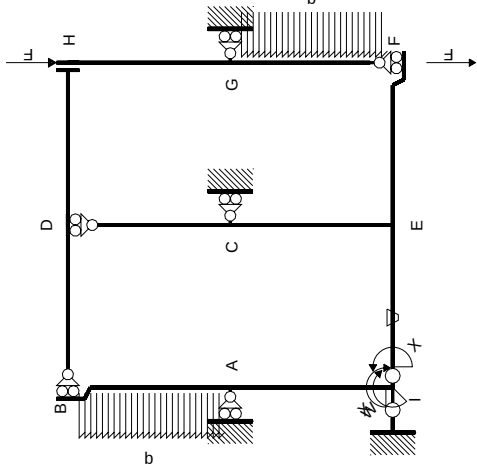


← ⊕ → F

↑ ⊕ ↓ F

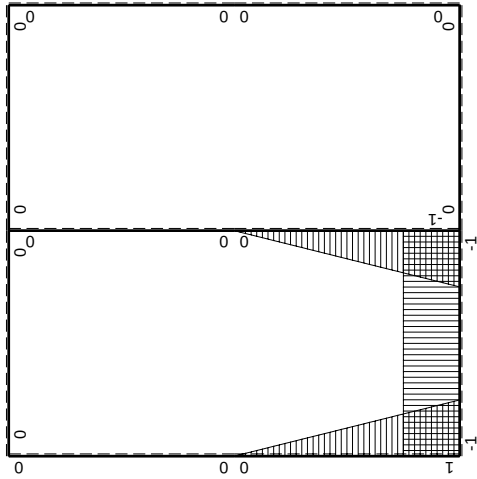


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x\theta} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x\theta} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

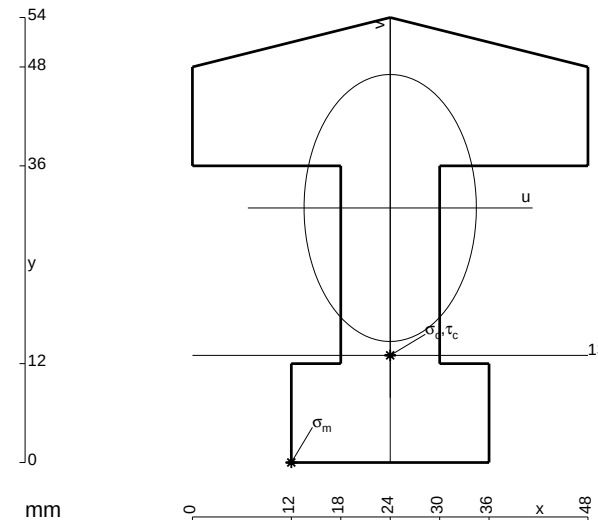
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

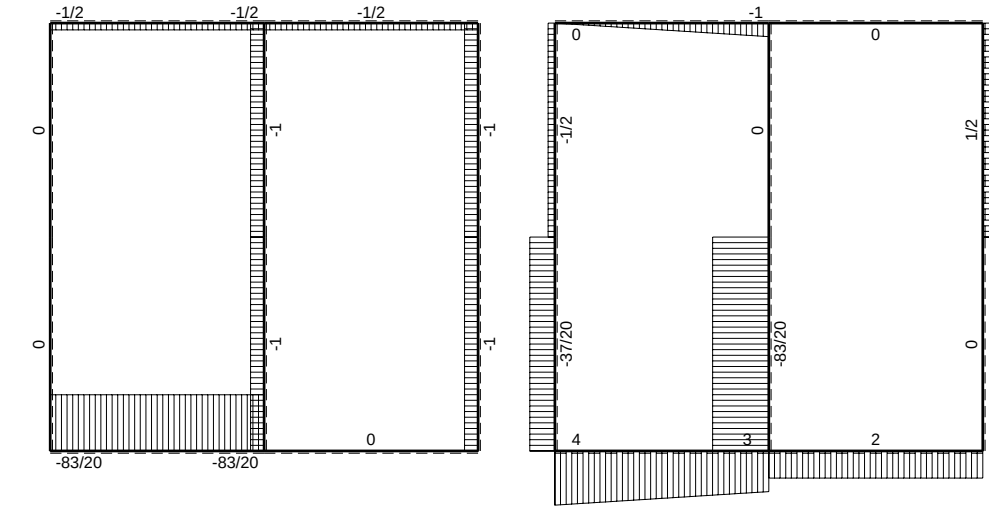
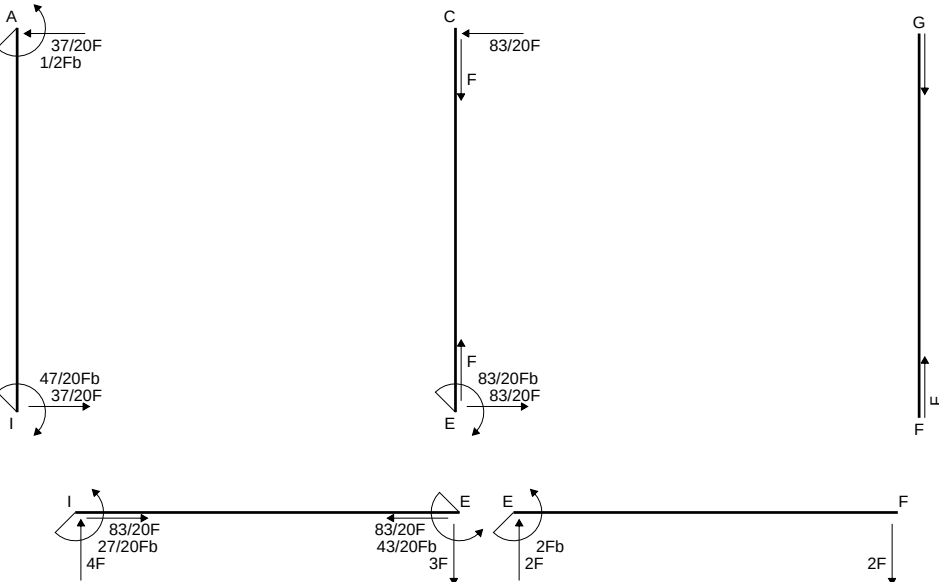
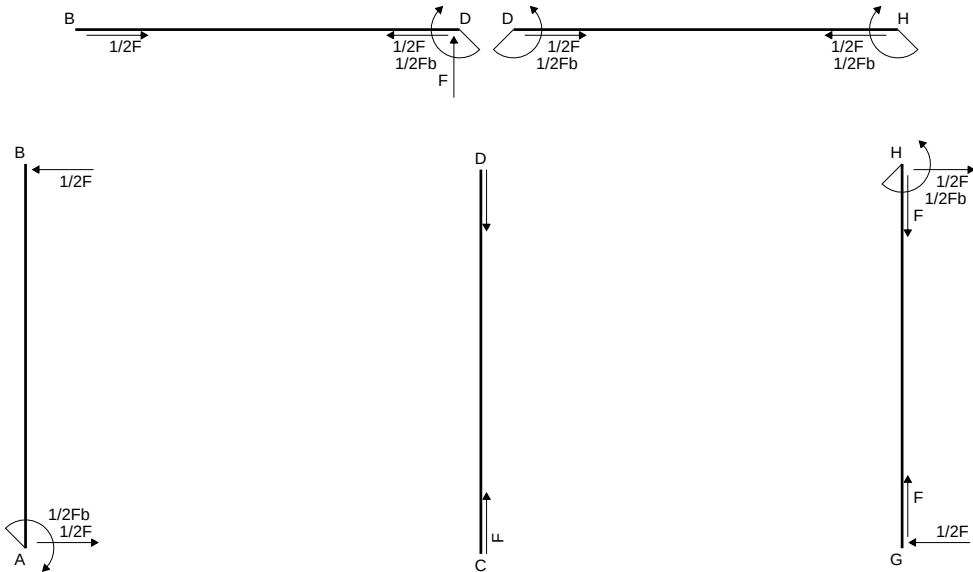
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

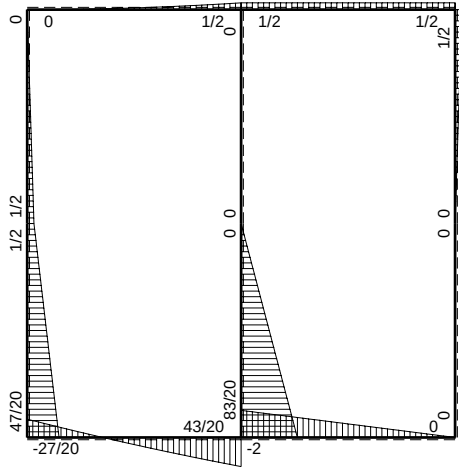


$$\begin{aligned} A &= 1296. \text{ mm}^2 \\ J_u &= 340256. \text{ mm}^4 \\ J_v &= 141696. \text{ mm}^4 \\ y_g &= 30.89 \text{ mm} \\ T_y &= 2600. \text{ N} \\ M_x &= -2522000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.89 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.89 \text{ mm} \\ \sigma_c &= -Mv/J_u = -132.6 \text{ N/mm}^2 \\ \tau_c &= 4.705 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 132.8 \text{ N/mm}^2 \\ S &= 7389. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ F_b

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-9/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$27/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

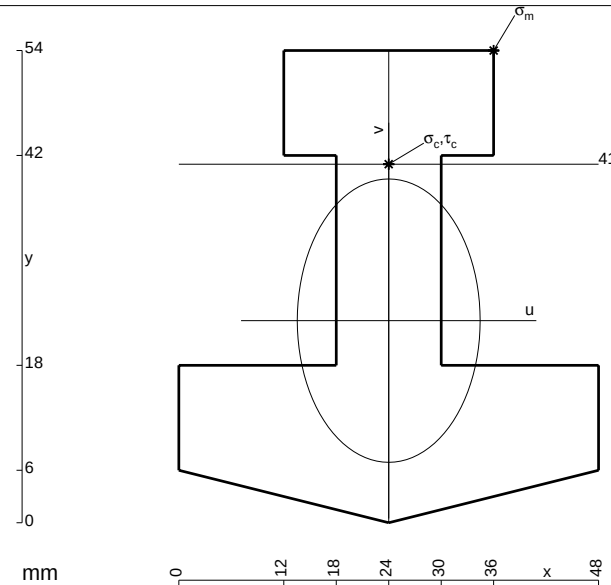
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



$$A = 1296. \text{ mm}^2$$

$$J_u = 340256. \text{ mm}^4$$

$$J_v = 141696. \text{ mm}^4$$

$$y_g = 23.11 \text{ mm}$$

$$T_y = 2580. \text{ N}$$

$$M_x = -2631600. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.89 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

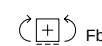
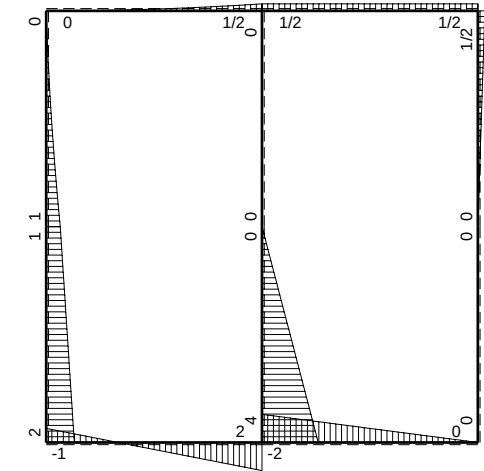
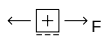
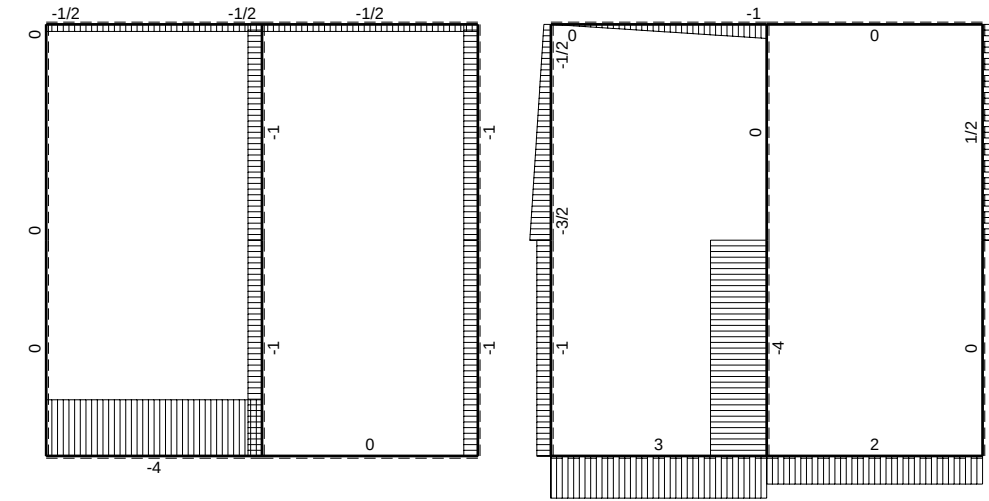
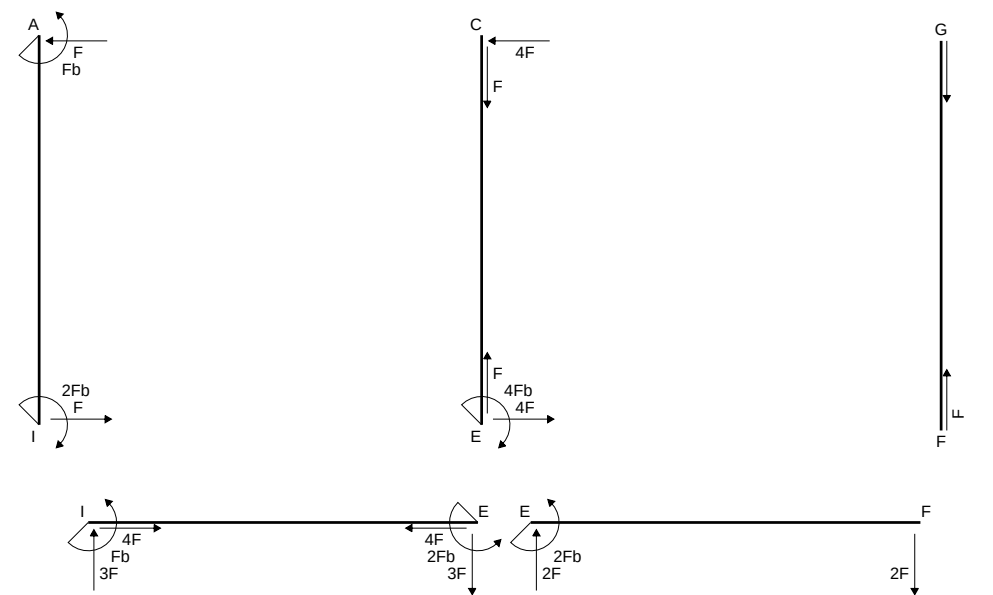
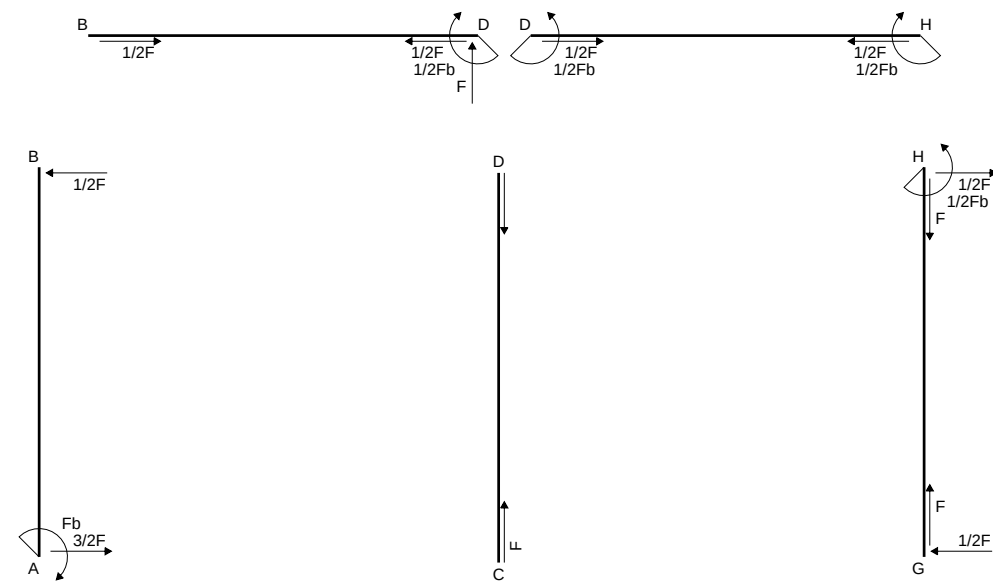
$$v_c = 17.89 \text{ mm}$$

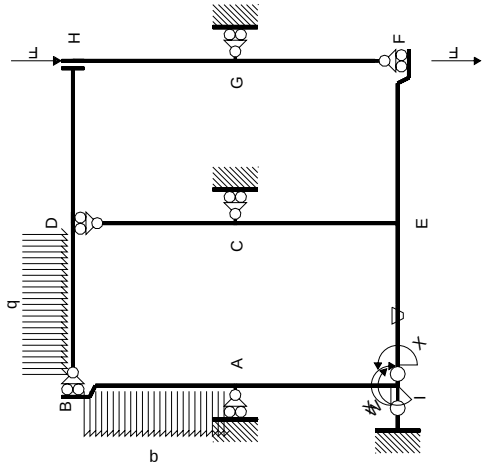
$$\sigma_c = -Mv/J_u = 138.4 \text{ N/mm}^2$$

$$\tau_c = 4.669 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 138.6 \text{ N/mm}^2$$

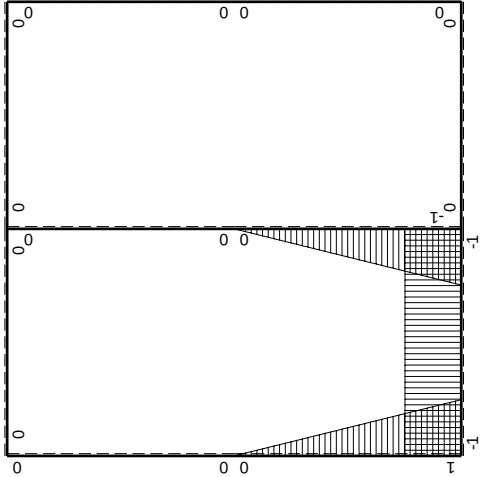
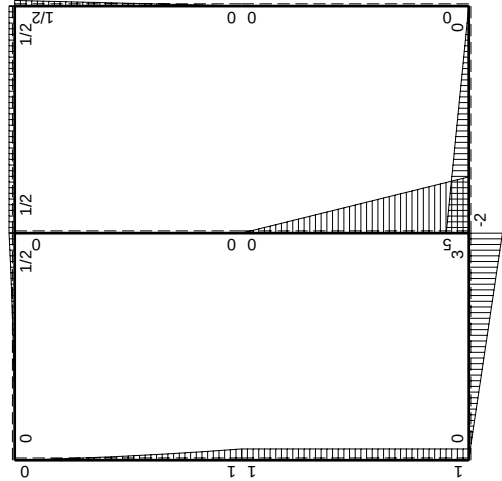
$$S = 7389. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb	0	$Fb-Fx$	0	$1-2x/b+x^2/b^2$	$(1/2+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb$	0	Fx	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

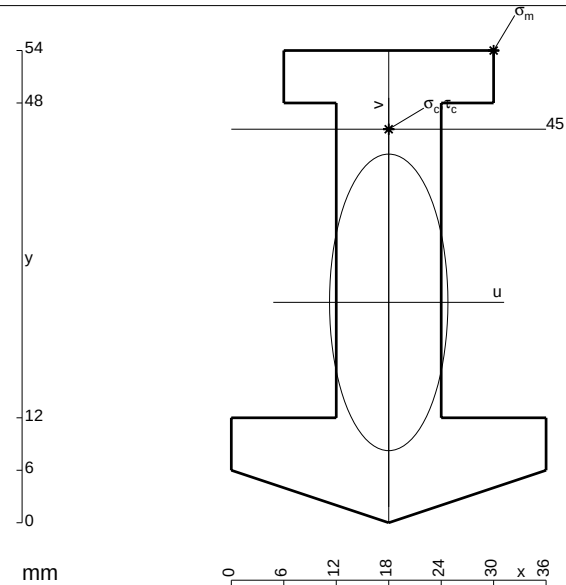
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - x/b) Fb \frac{1}{EJ} dx = \left[x - 1/2 x^2/b \right]_0^b Fb \frac{1}{EJ}$$

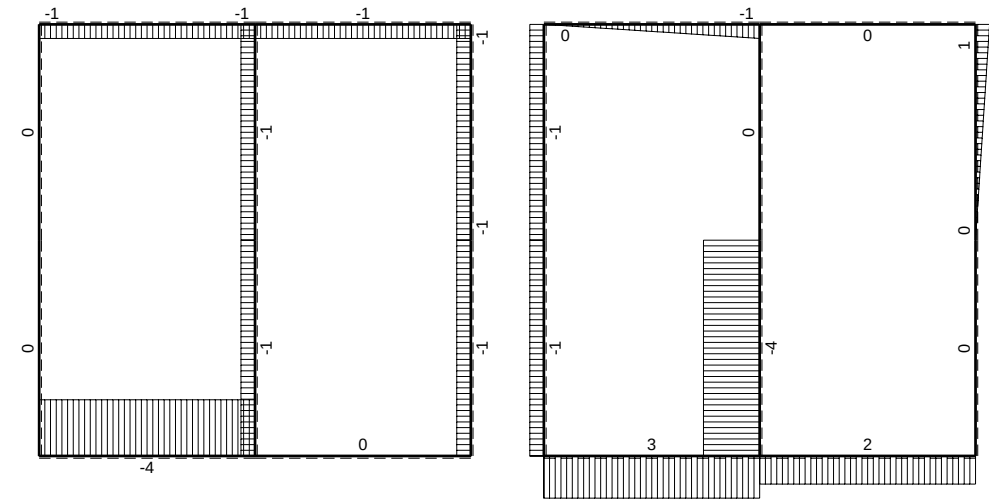
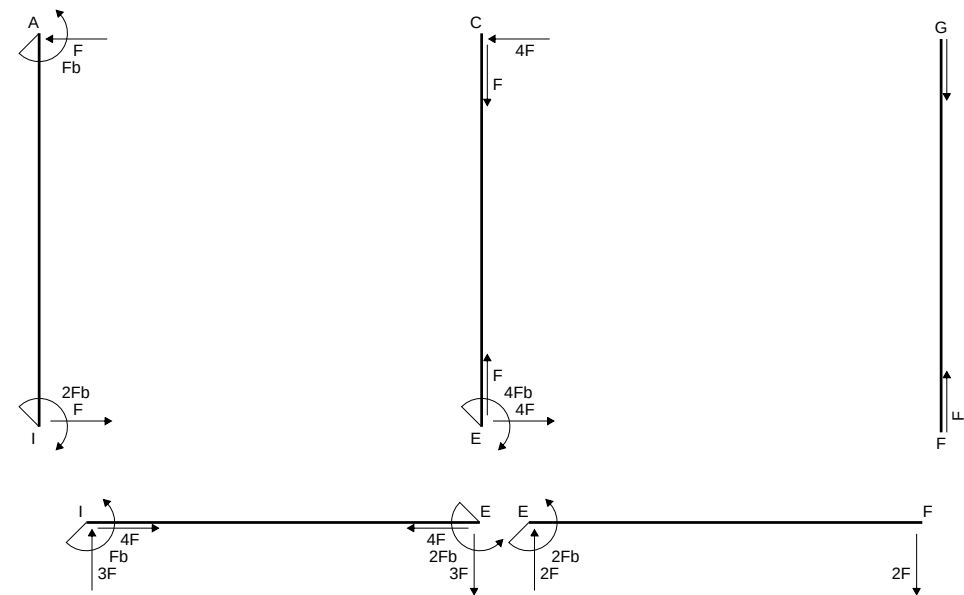
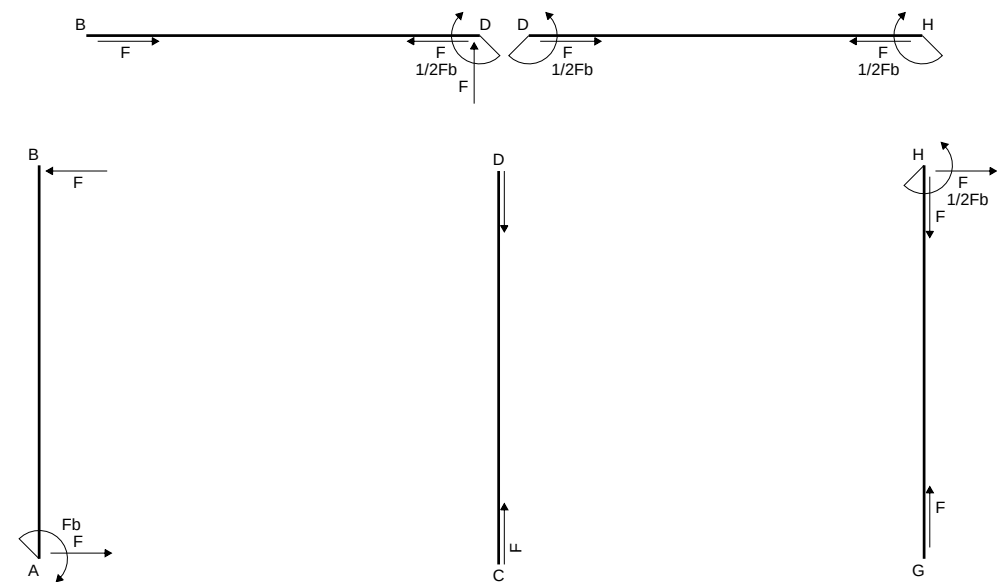
$$= (b - 1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

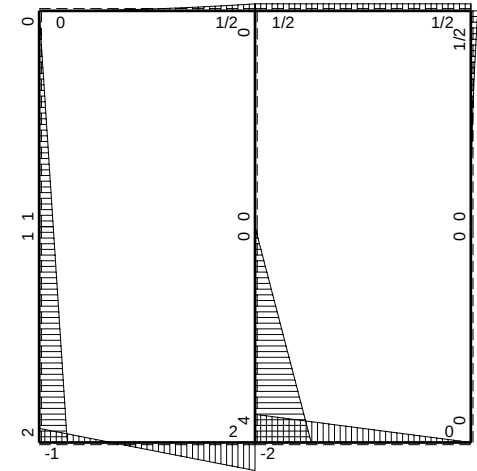


$$\begin{aligned} A &= 900. \text{ mm}^2 \\ J_u &= 258984. \text{ mm}^4 \\ J_v &= 41256. \text{ mm}^4 \\ y_g &= 25.2 \text{ mm} \\ T_y &= 3320. \text{ N} \\ M_x &= -1792800. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.8 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.4 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 19.8 \text{ mm} \\ \sigma_c &= -Mv/J_u = 137.1 \text{ N/mm}^2 \\ \tau_c &= 4.788 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 137.3 \text{ N/mm}^2 \\ S &= 4482. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-Fx$	0	0	0	0	0+0	0
BA b	0	$-Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb	0	$Fb-Fx$	0	$1-2x/b+x^2/b^2$	$(1/2+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb$	0	Fx	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

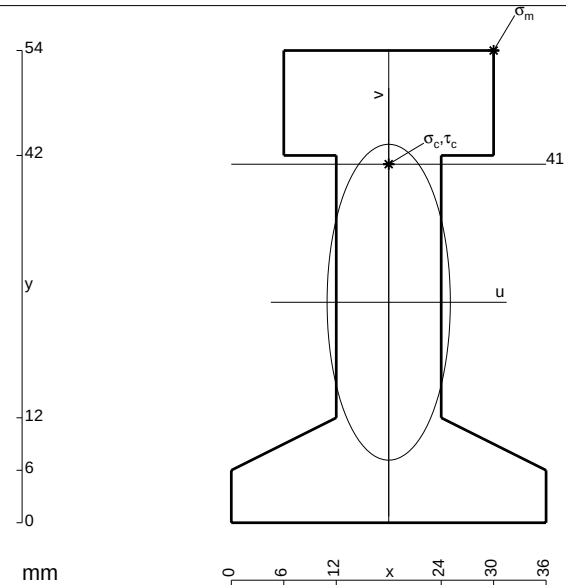
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - x/b) Fb \frac{1}{EJ} dx = \left[x - 1/2 x^2/b \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$



$$A = 1008. \text{ mm}^2$$

$$J_u = 328994. \text{ mm}^4$$

$$J_v = 50112. \text{ mm}^4$$

$$y_g = 25.21 \text{ mm}$$

$$T_y = 4060. \text{ N}$$

$$M_x = -2395400. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.79 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

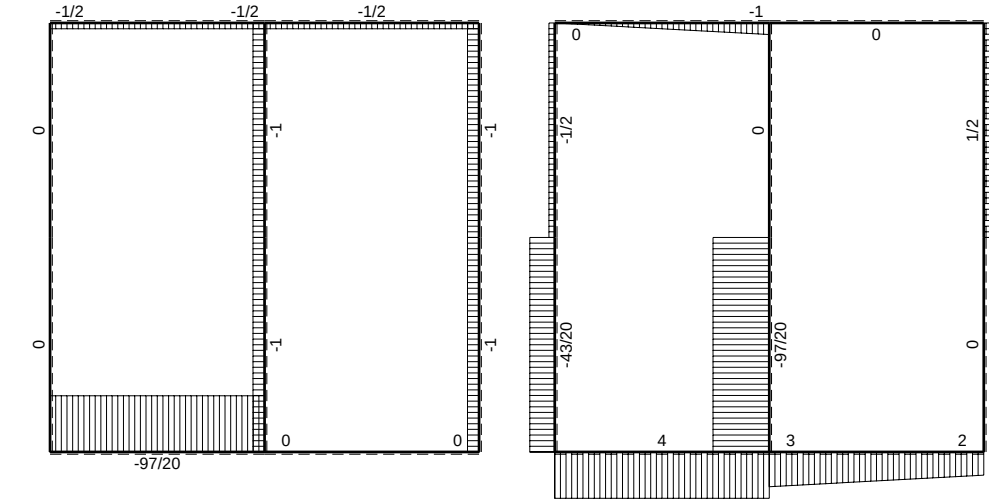
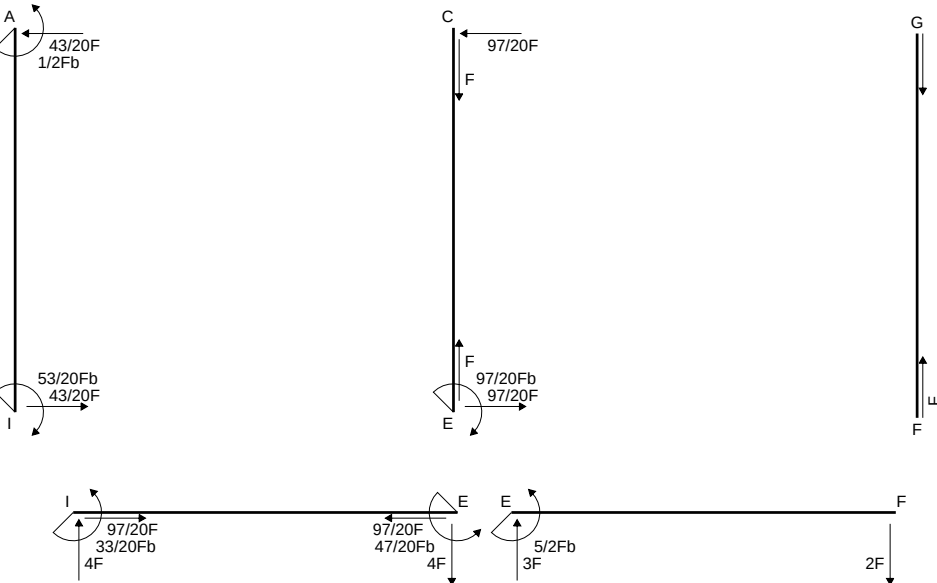
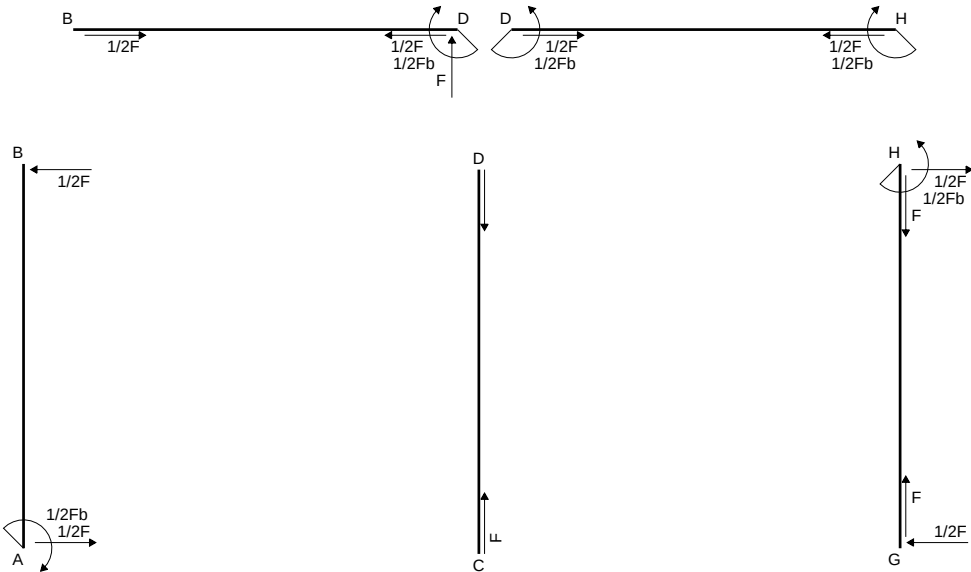
$$v_c = 15.79 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 114.9 \text{ N/mm}^2$$

$$\tau_c = 6.95 \text{ N/mm}^2$$

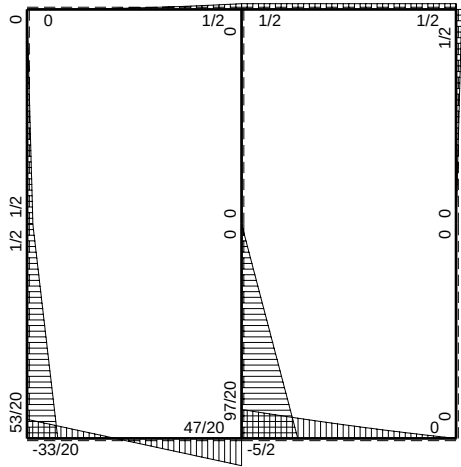
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 115.6 \text{ N/mm}^2$$

$$S = 6758. \text{ mm}^3$$

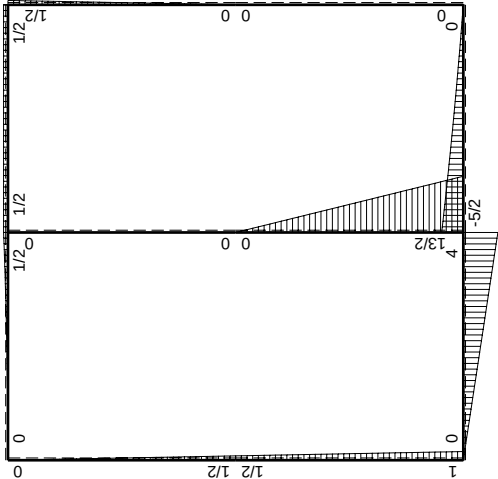
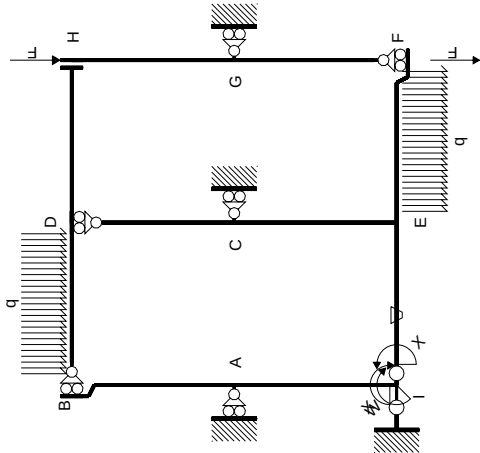


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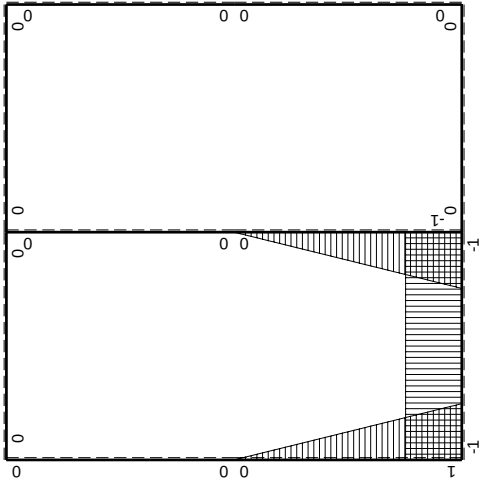


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

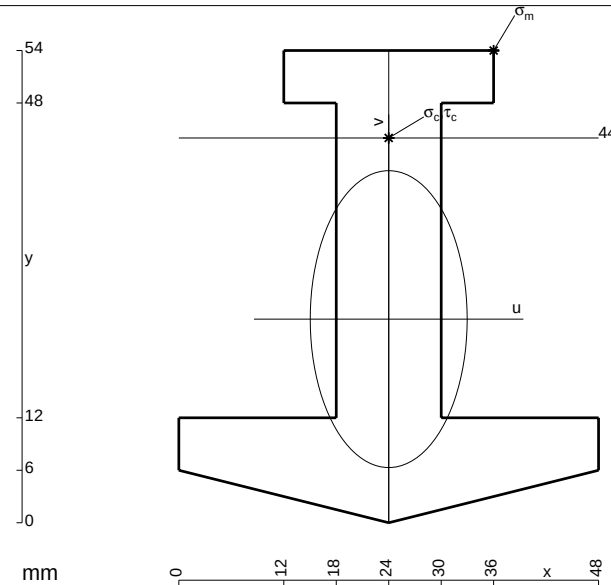
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



$$A = 1008. \text{ mm}^2$$

$$J_u = 290654. \text{ mm}^4$$

$$J_v = 81216. \text{ mm}^4$$

$$y_g = 23.29 \text{ mm}$$

$$T_y = 3900. \text{ N}$$

$$M_x = -2080000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.71 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

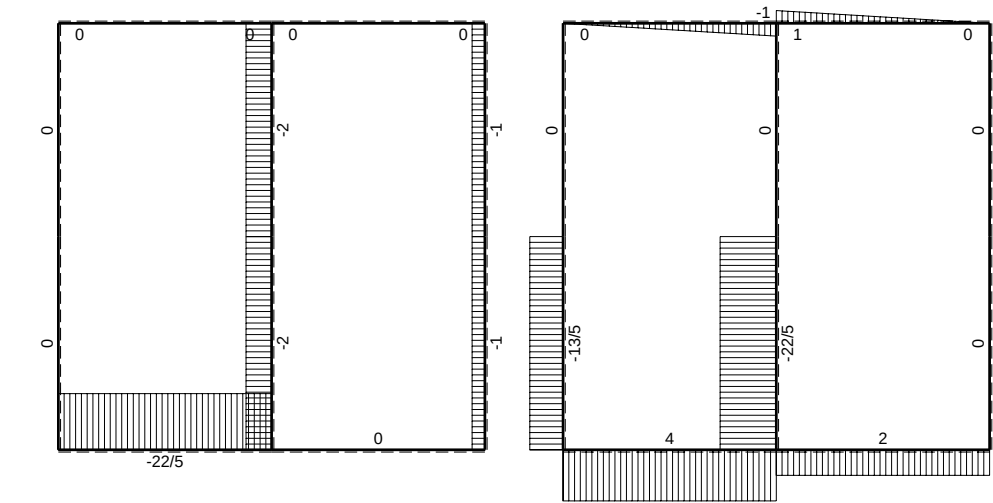
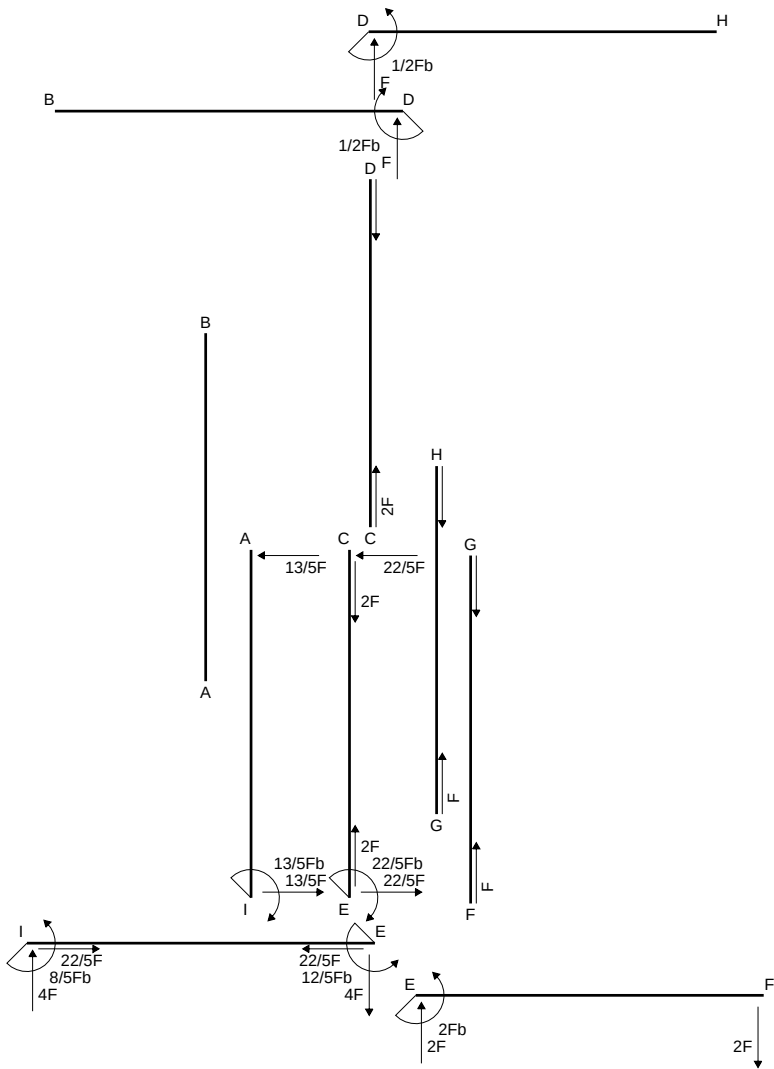
$$v_c = 20.71 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 148.2 \text{ N/mm}^2$$

$$\tau_c = 5.682 \text{ N/mm}^2$$

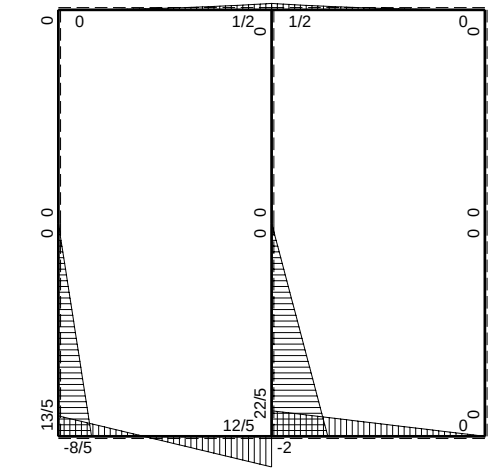
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 148.6 \text{ N/mm}^2$$

$$S = 5081. \text{ mm}^3$$

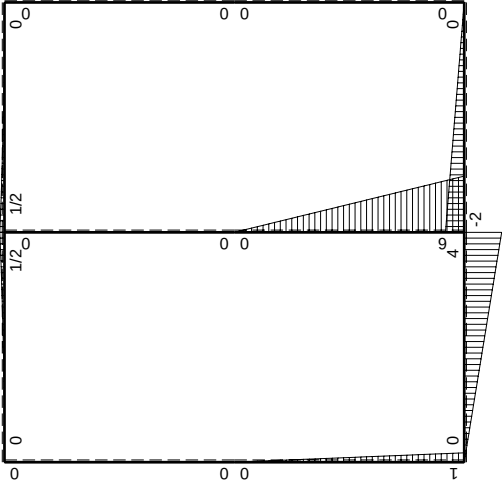
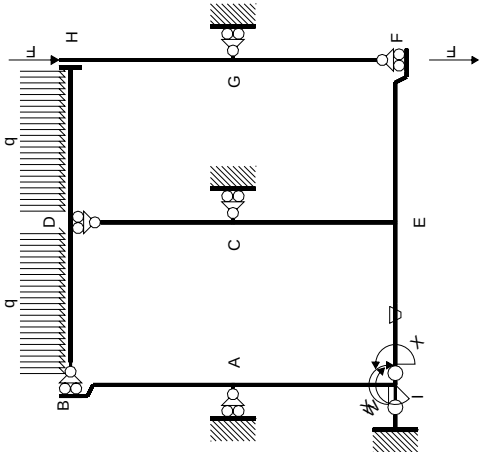


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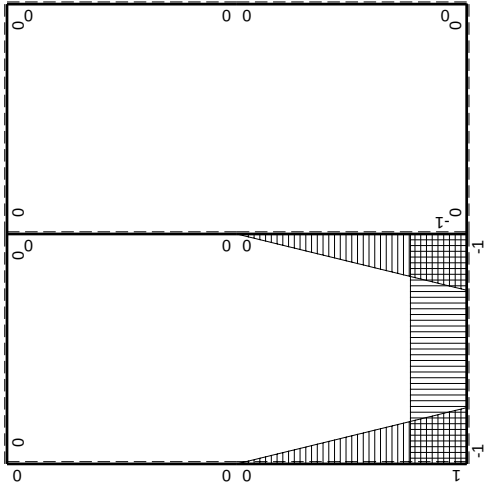


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

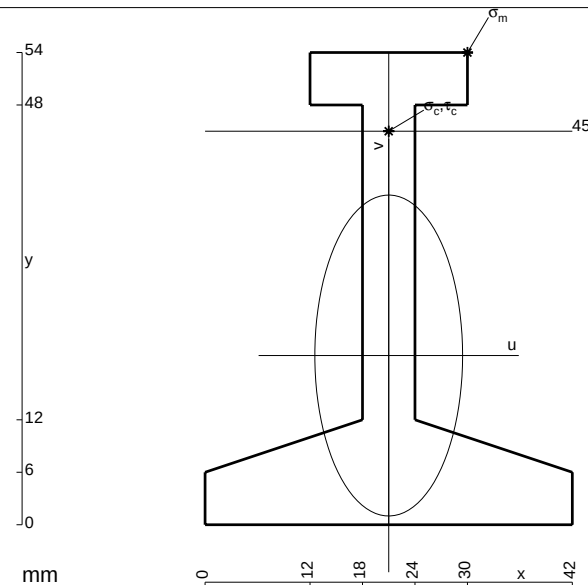
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

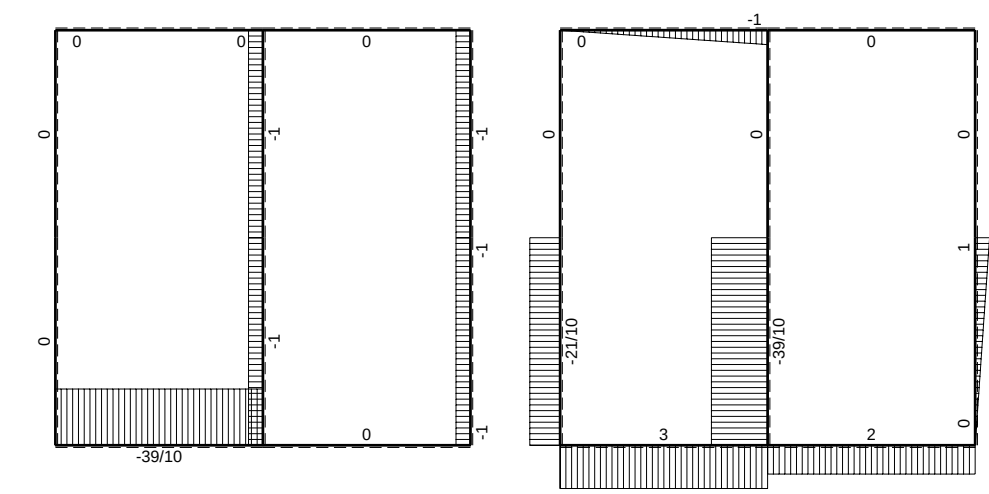
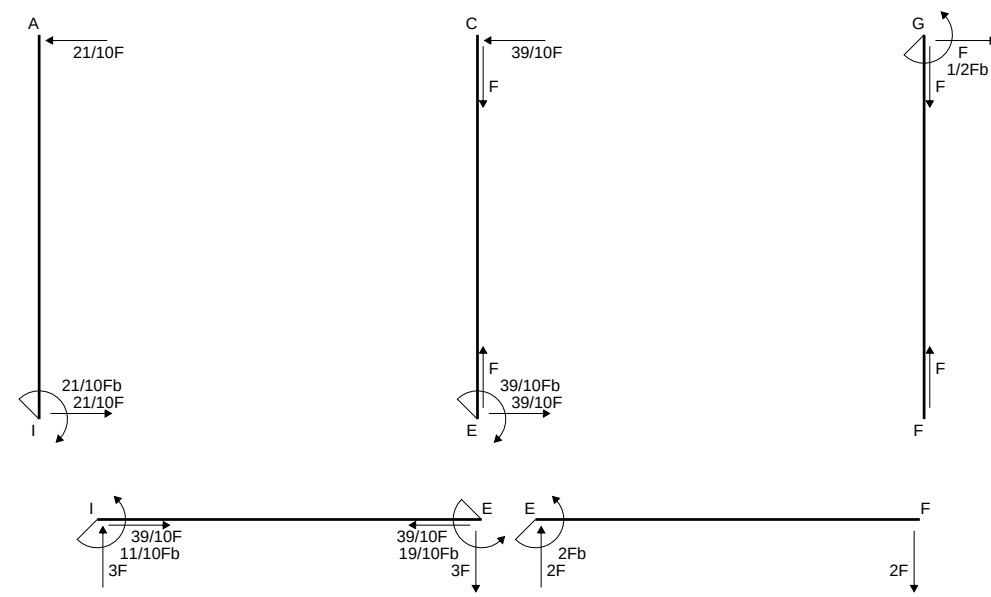
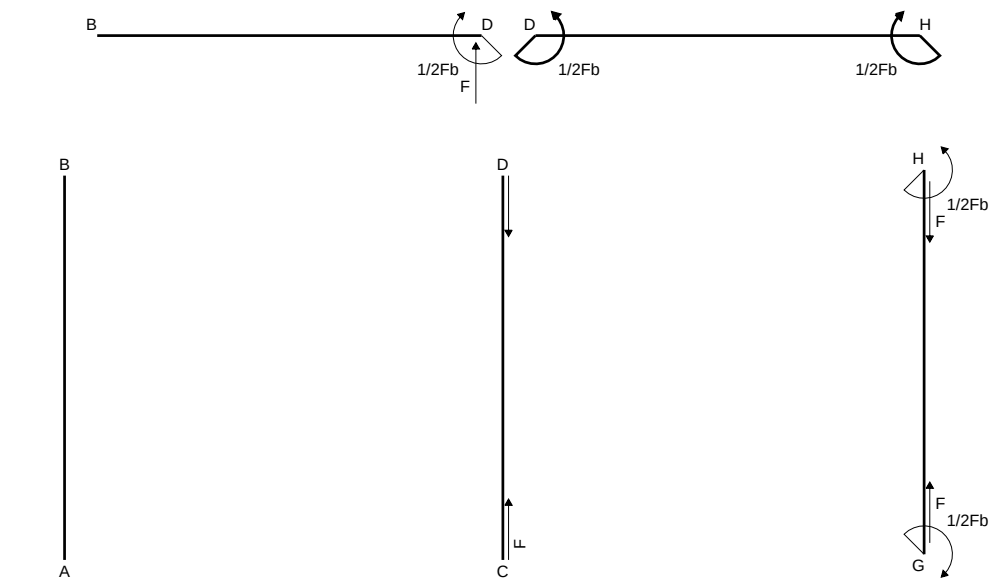
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

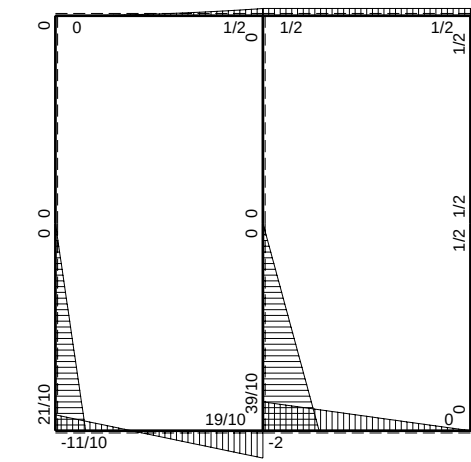


$$\begin{aligned} A &= 720. \text{ mm}^2 \\ J_u &= 242552. \text{ mm}^4 \\ J_v &= 51408. \text{ mm}^4 \\ y_g &= 19.35 \text{ mm} \\ T_y &= 2300. \text{ N} \\ M_x &= -1610000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 34.65 \text{ mm} \\ \sigma_m &= -Mv/J_u = 230. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 25.65 \text{ mm} \\ \sigma_c &= -Mv/J_u = 170.3 \text{ N/mm}^2 \\ \tau_c &= 6.175 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 170.6 \text{ N/mm}^2 \\ S &= 3907. \text{ mm}^3 \end{aligned}$$

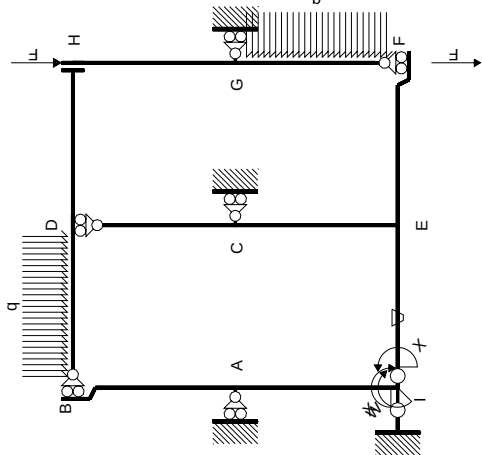


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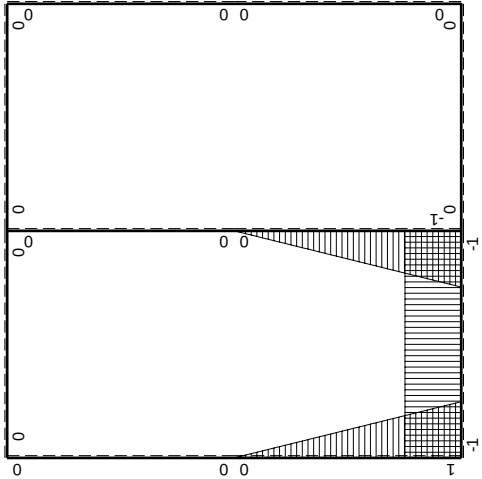
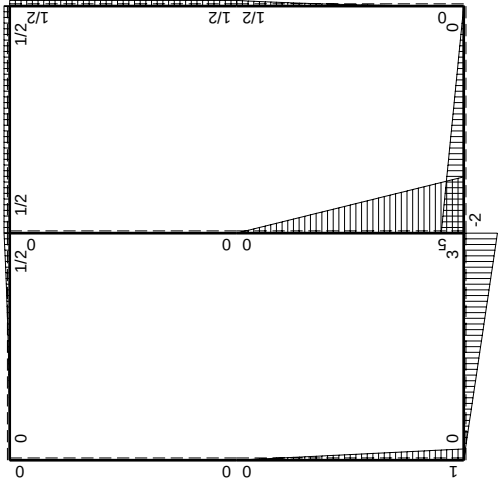


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

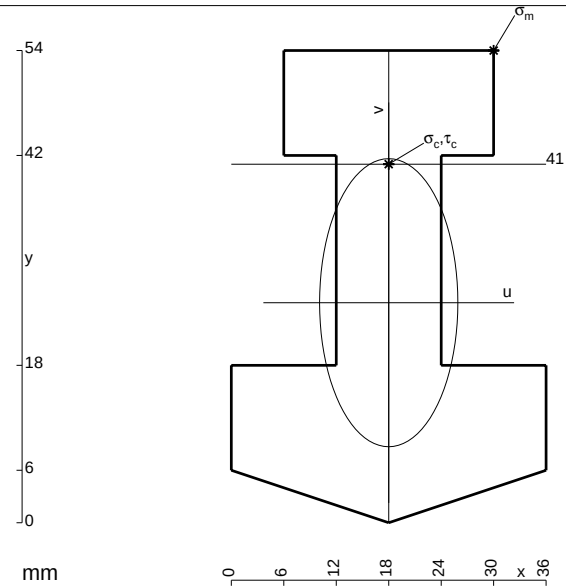
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$



$$A = 1116. \text{ mm}^2$$

$$J_u = 302839. \text{ mm}^4$$

$$J_v = 69768. \text{ mm}^4$$

$$y_g = 25.16 \text{ mm}$$

$$T_y = 3360. \text{ N}$$

$$M_x = -2520000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.84 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 240. \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

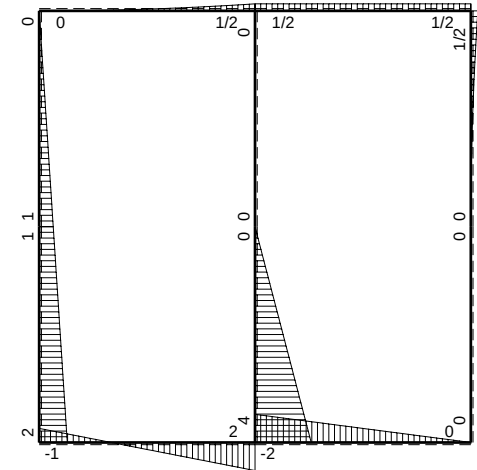
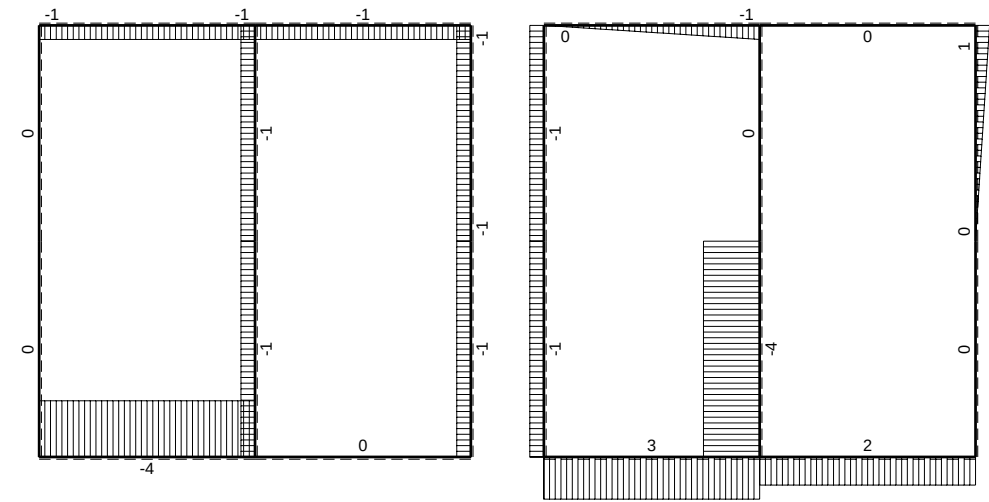
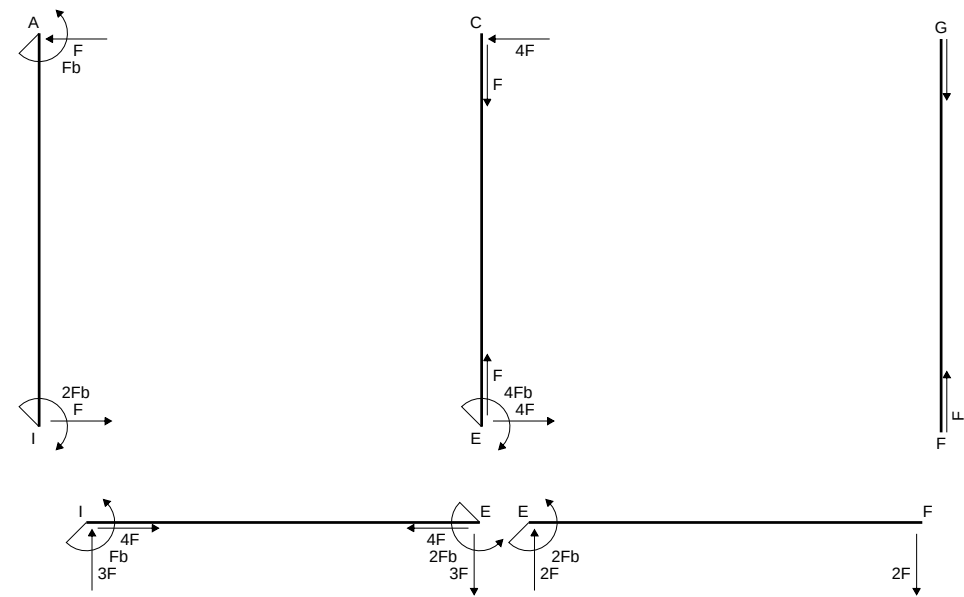
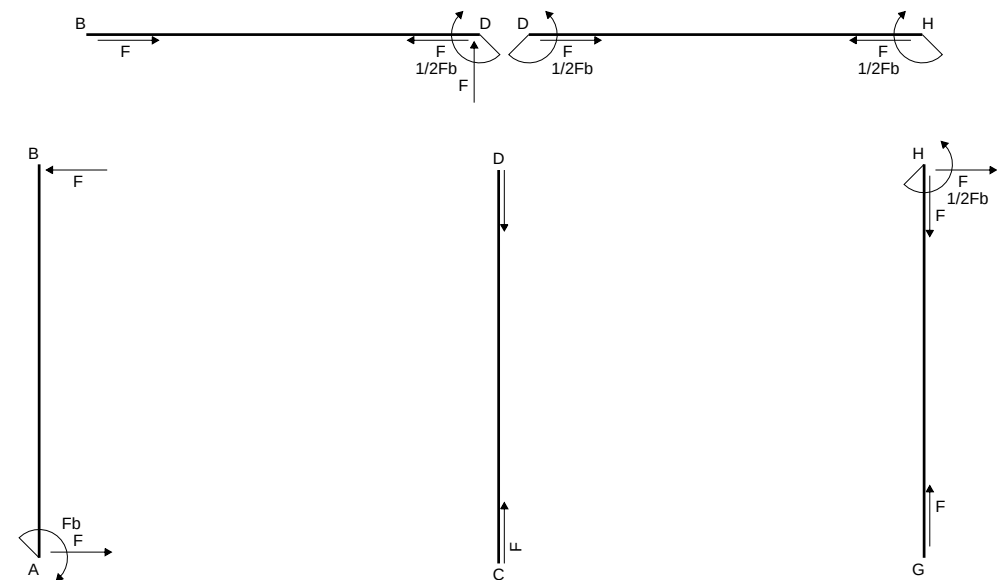
$$v_c = 15.84 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 131.8 \text{ N/mm}^2$$

$$\tau_c = 6.263 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 132.2 \text{ N/mm}^2$$

$$S = 6774. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$Fb-Fx$	0	0	0	0	0+0	0
BA b	0	$-Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fb	0	$Fb-Fx$	0	$1-2x/b+x^2/b^2$	$(1/2+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb$	0	Fx	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

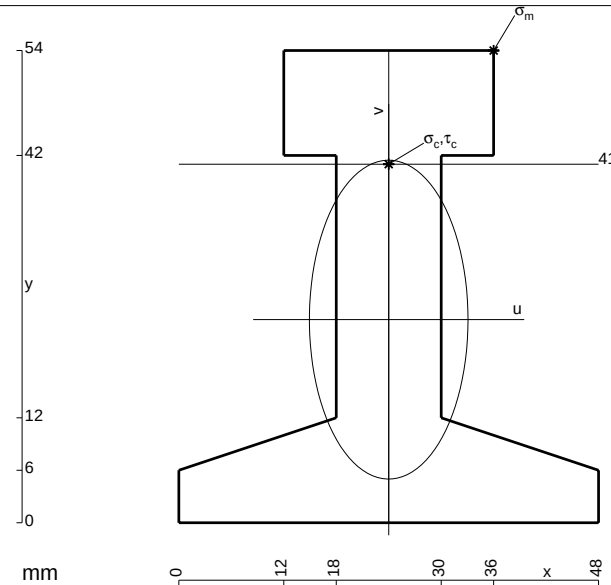
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - x/b) Fb \frac{1}{EJ} dx = \left[x - 1/2 x^2/b \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b) Fb \frac{1}{EJ} = 1/2 Fb^2/EJ$$



$$A = 1116. \text{ mm}^2$$

$$J_u = 371067. \text{ mm}^4$$

$$J_v = 91800. \text{ mm}^4$$

$$y_g = 23.23 \text{ mm}$$

$$T_y = 2960. \text{ N}$$

$$M_x = -2397600. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.77 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 198.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

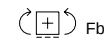
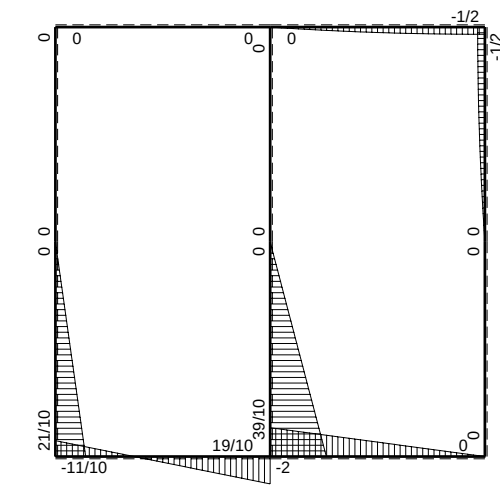
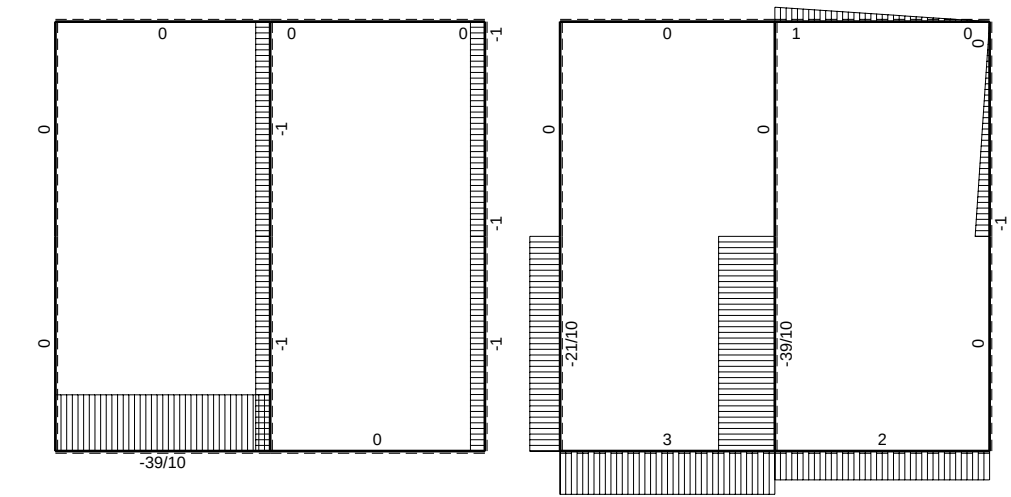
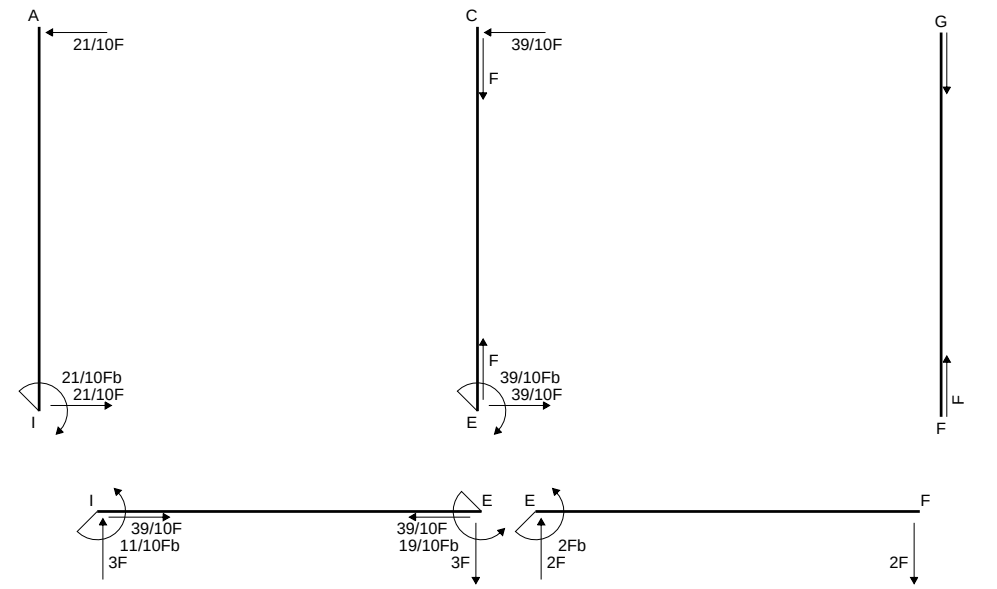
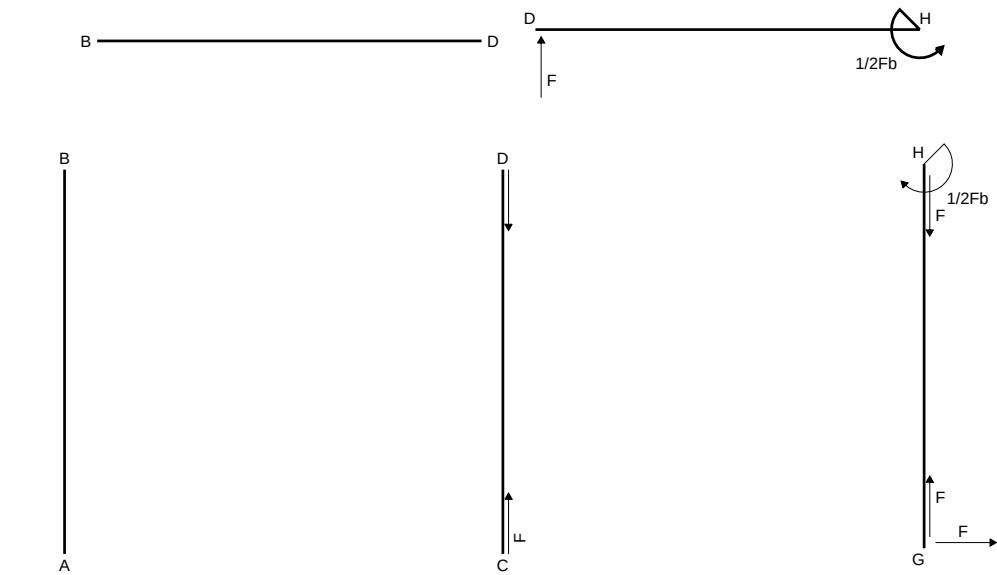
$$v_c = 17.77 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 114.8 \text{ N/mm}^2$$

$$\tau_c = 4.889 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 115.2 \text{ N/mm}^2$$

$$S = 7354. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

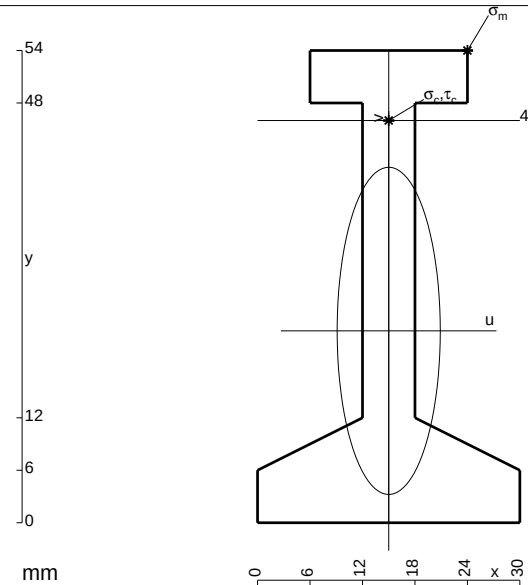
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$



$$A = 612. \text{ mm}^2$$

$$J_u = 214270. \text{ mm}^4$$

$$J_v = 21276. \text{ mm}^4$$

$$y_g = 21.94 \text{ mm}$$

$$T_y = 1620. \text{ N}$$

$$M_x = -1393200. \text{ Nmm}$$

$$x_m = 24. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 32.06 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.4 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

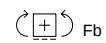
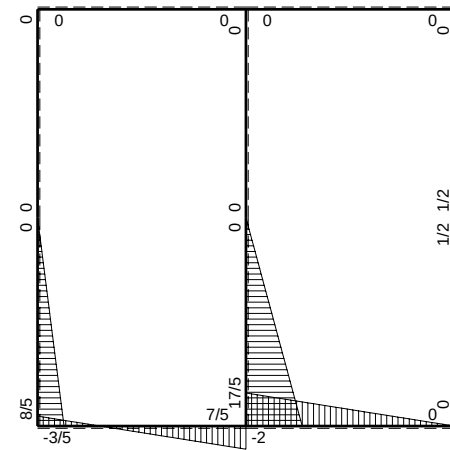
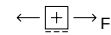
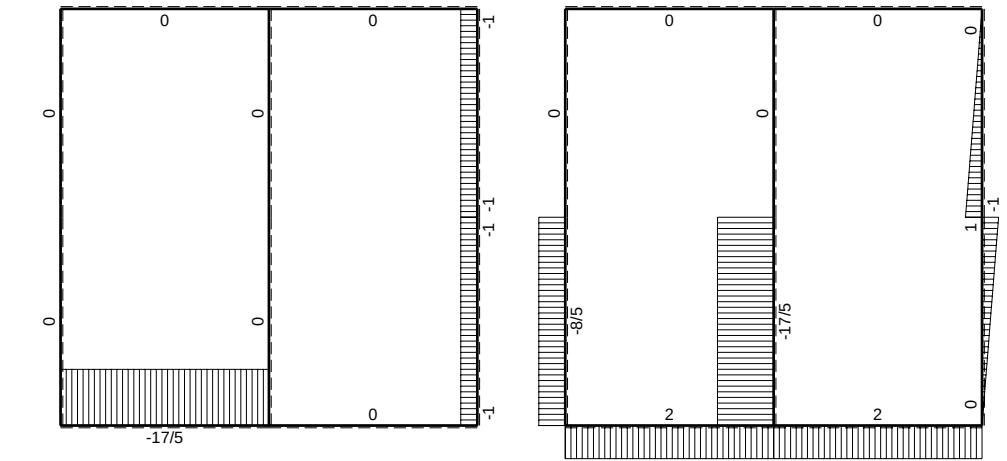
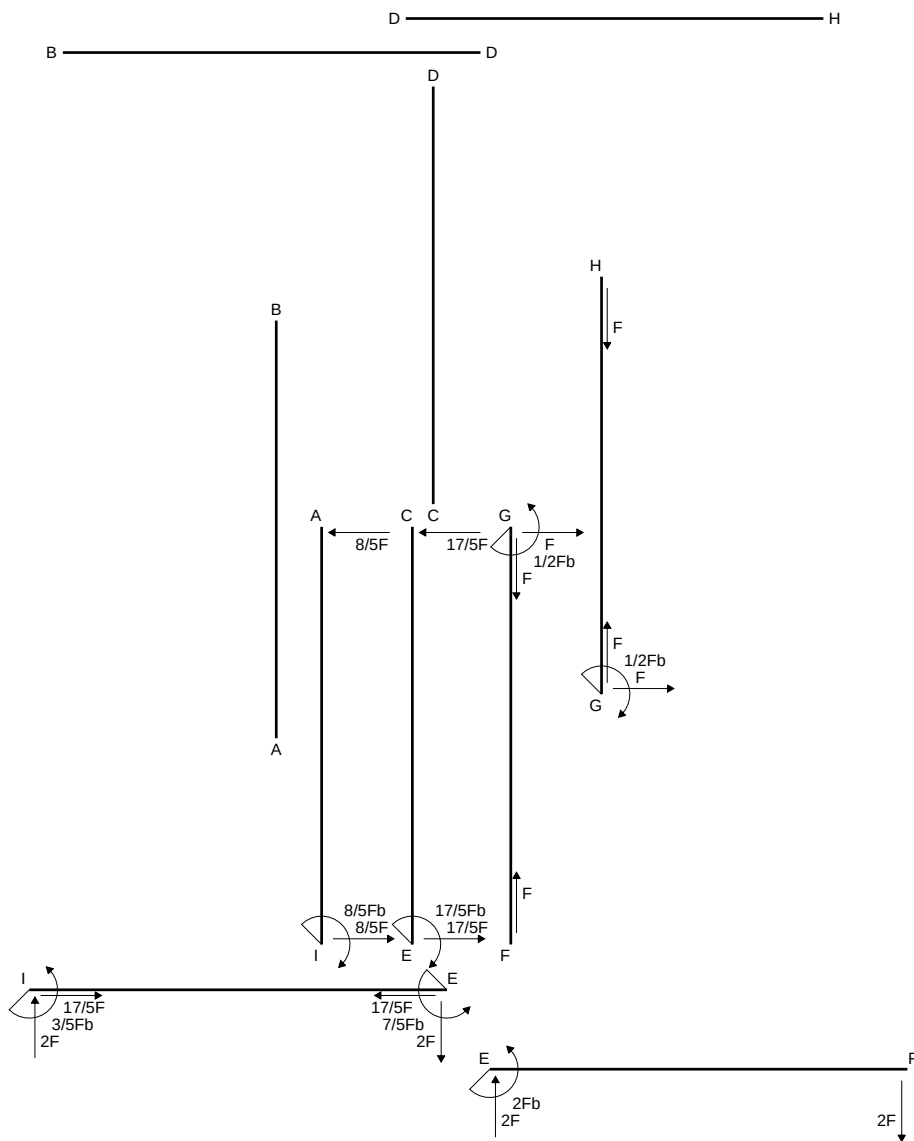
$$v_c = 24.06 \text{ mm}$$

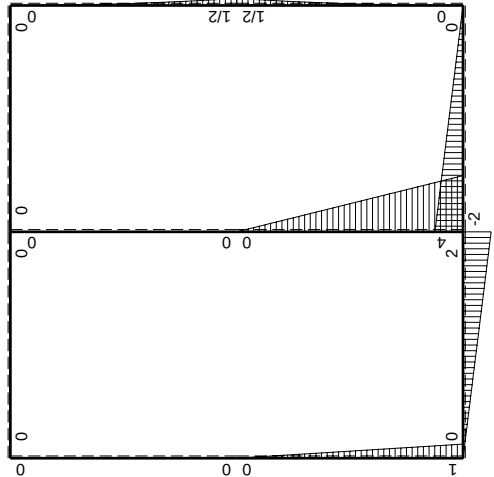
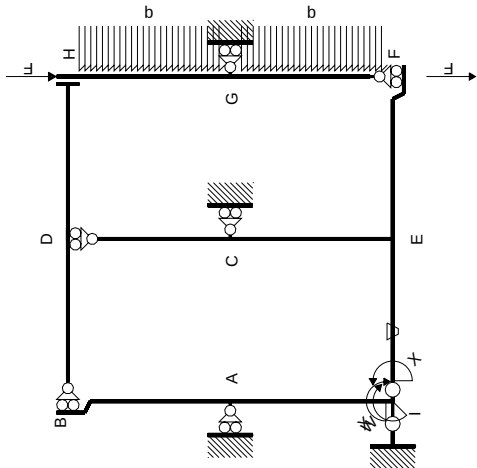
$$\sigma_c = -Mv/J_u = 156.4 \text{ N/mm}^2$$

$$\tau_c = 4.334 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 156.6 \text{ N/mm}^2$$

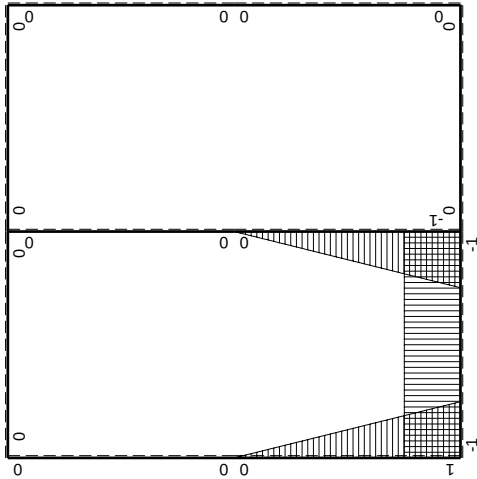
$$S = 3439. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

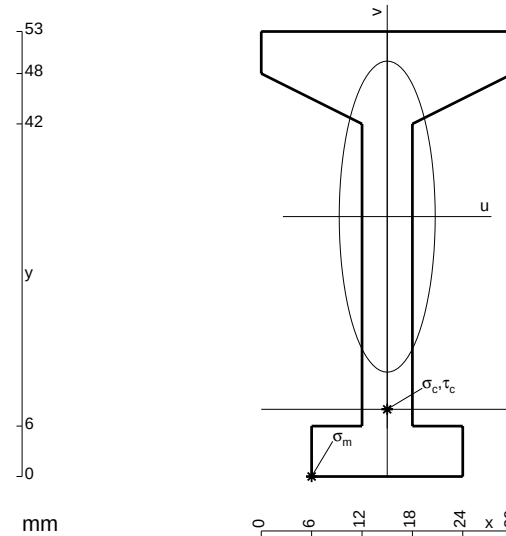
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$



$$A = 582. \text{ mm}^2$$

$$J_u = 199765. \text{ mm}^4$$

$$J_v = 19026. \text{ mm}^4$$

$$y_g = 30.95 \text{ mm}$$

$$T_y = 1560. \text{ N}$$

$$M_x = -1404000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -30.95 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -217.6 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 8. \text{ mm}$$

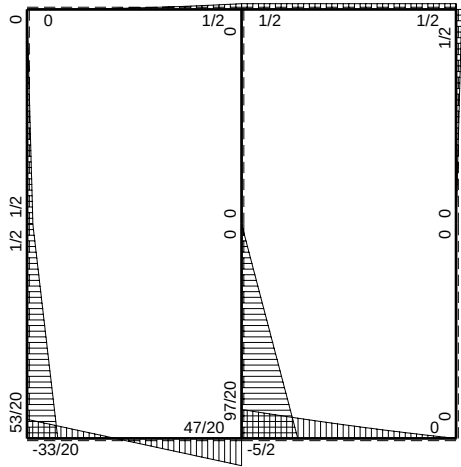
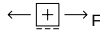
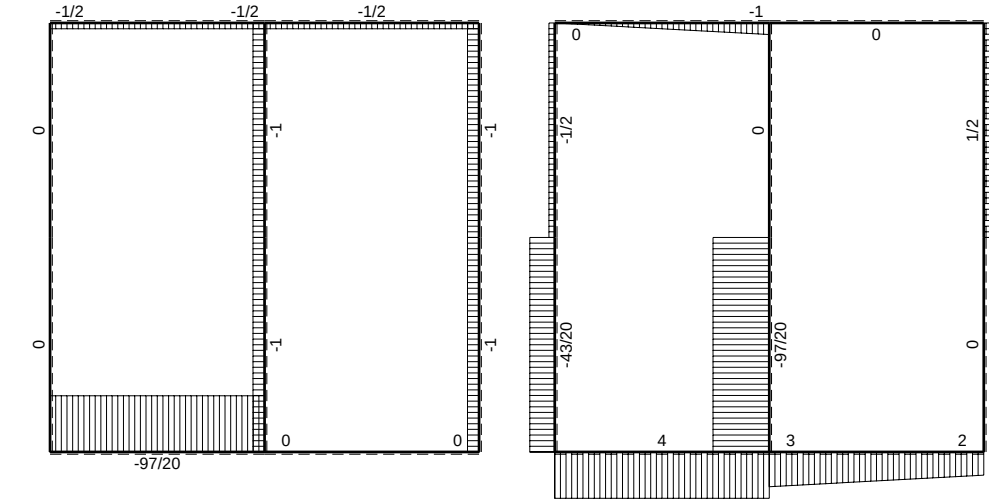
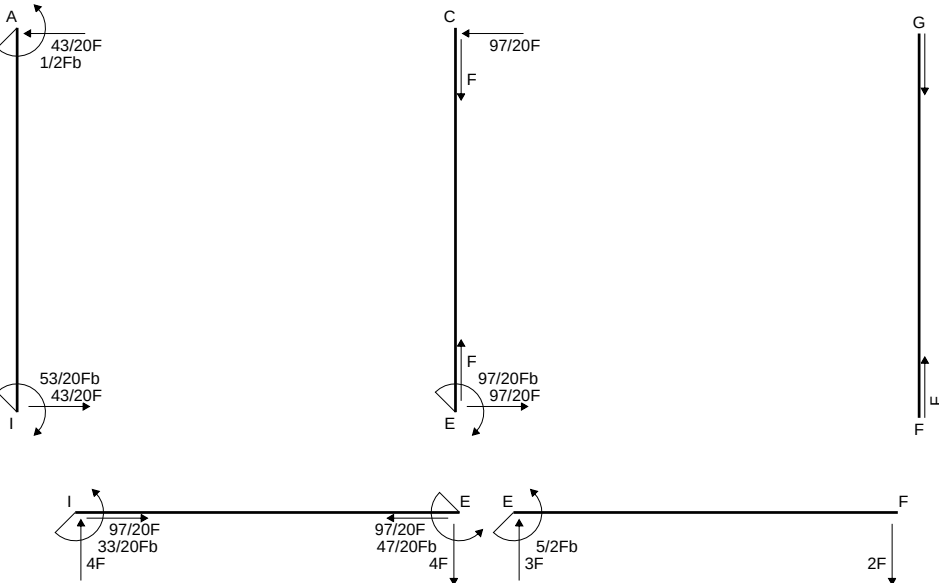
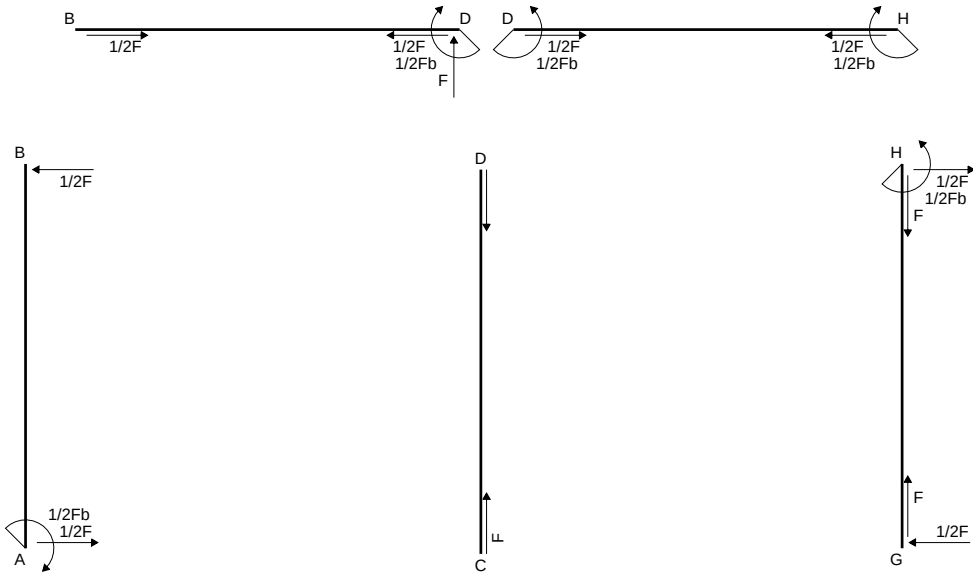
$$v_c = -22.95 \text{ mm}$$

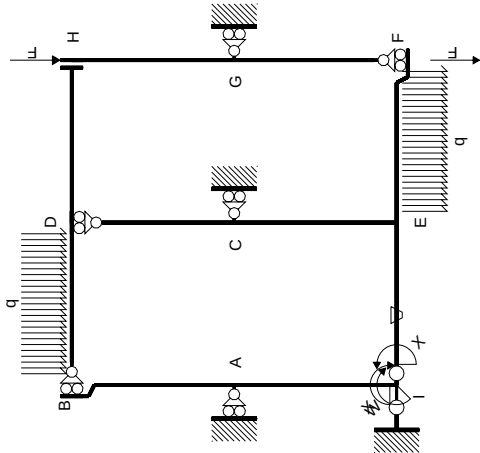
$$\sigma_c = -Mv/J_u = -161.3 \text{ N/mm}^2$$

$$\tau_c = 4.303 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 161.5 \text{ N/mm}^2$$

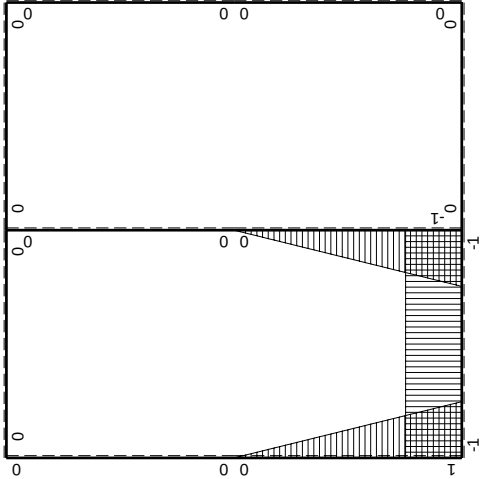
$$S = 3306. \text{ mm}^3$$



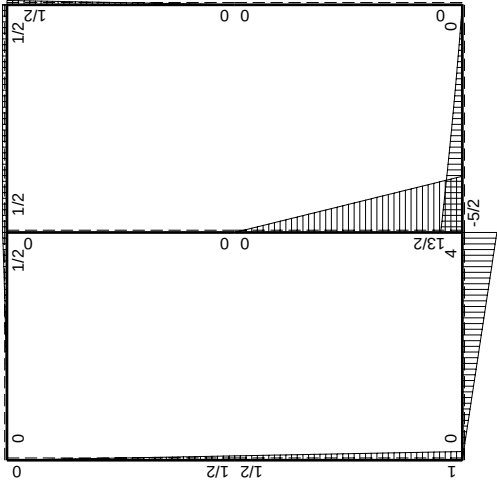


Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2 Fb - 1/2 Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2 Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2 Fb + 3Fx - 1/2 qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx + 1/2 qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2 Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2 Fb + 1/2 Fx$	0	0	0	0		
HD b	0	$1/2 Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2 Fb$	0	0	0	0		
DB b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2 qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2 Fb - 13/2 Fx$	0	$-13/2 Fb + 13Fx - 13/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3 Xb/EJ$
CE b	x/b	$-13/2 Fx$	0	$-13/2 Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb - 1/2 Fx$	0	$Fb - 3/2 Fx + 1/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3 Xb/EJ$
AI b	$-x/b$	$-1/2 Fb - 1/2 Fx$	0	$1/2 Fx + 1/2 Fx^2/b$	0	x^2/b^2		
	totali						$-11/4 Fb^2/EJ$	$5/3 Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20 Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

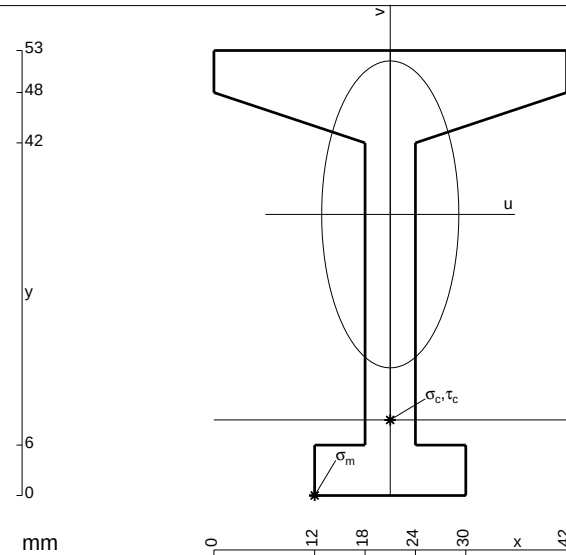
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



$$A = 678. \text{ mm}^2$$

$$J_u = 226700. \text{ mm}^4$$

$$J_v = 45234. \text{ mm}^4$$

$$y_g = 33.48 \text{ mm}$$

$$T_y = 1950. \text{ N}$$

$$M_x = -1543750. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.48 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -228. \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

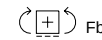
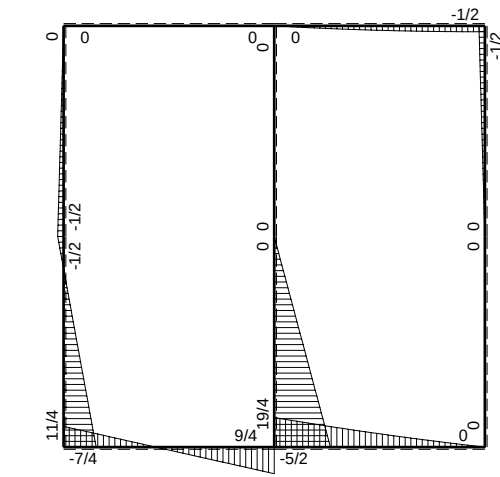
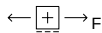
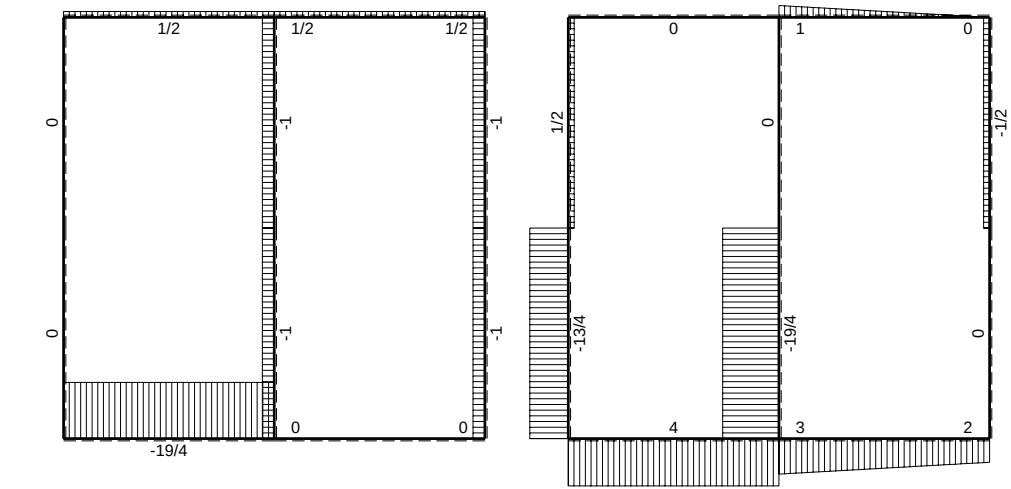
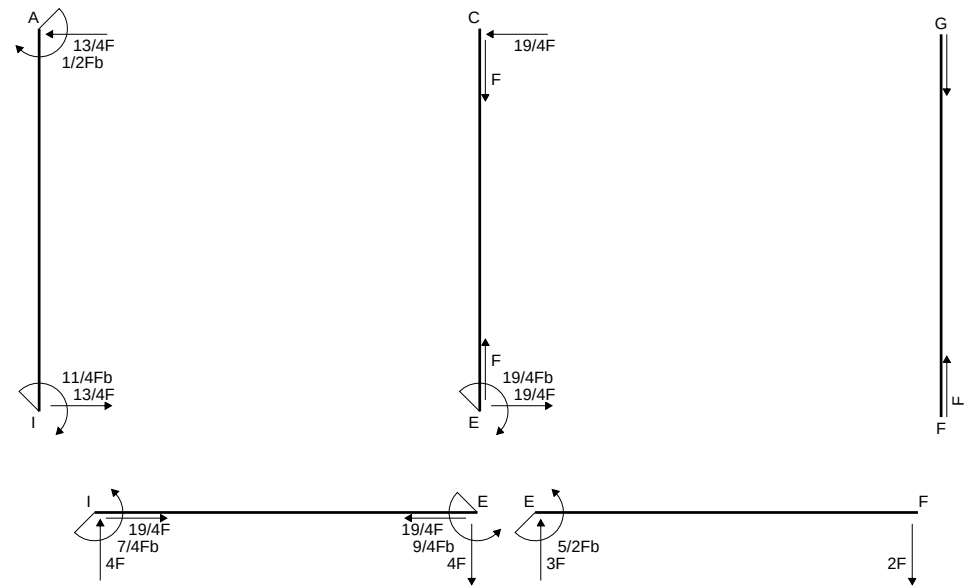
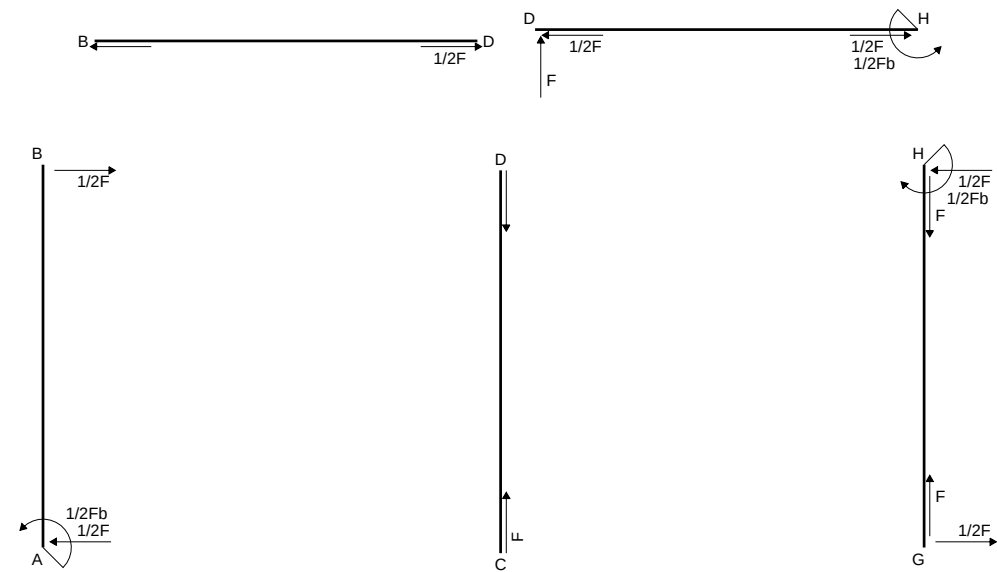
$$v_c = -24.48 \text{ mm}$$

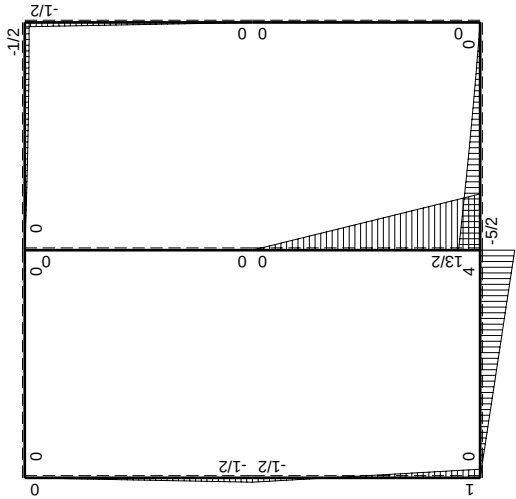
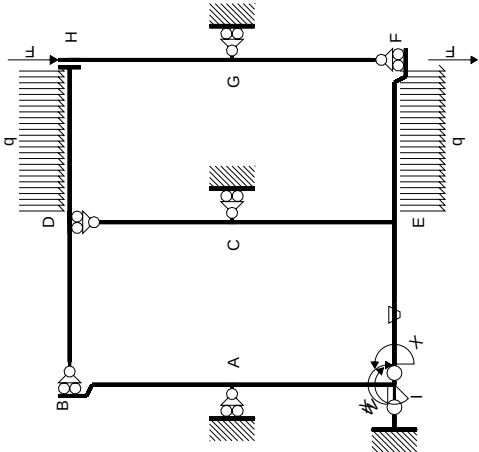
$$\sigma_c = -Mv/J_u = -166.7 \text{ N/mm}^2$$

$$\tau_c = 5.39 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 167. \text{ N/mm}^2$$

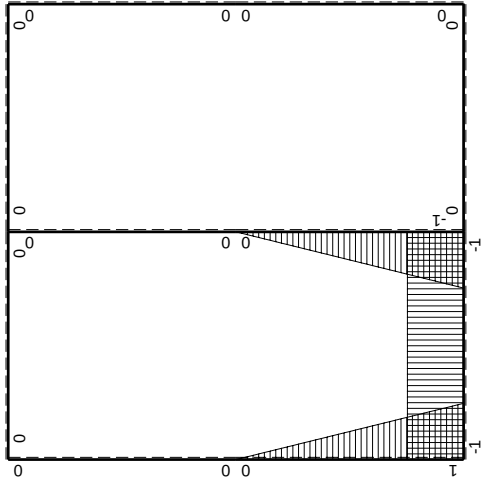
$$S^* = 3760. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

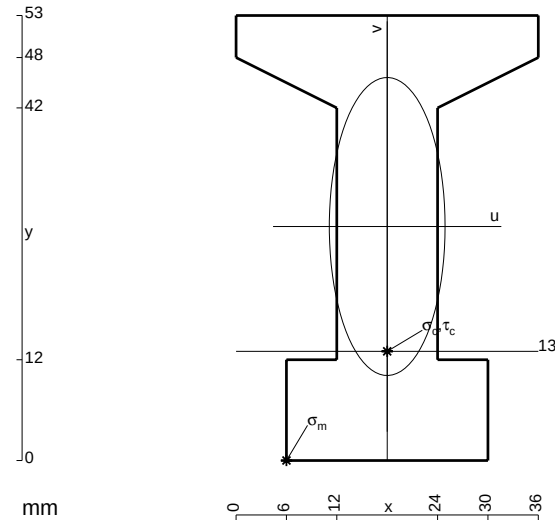
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 972. \text{ mm}^2$$

$$J_u = 306188. \text{ mm}^4$$

$$J_v = 46224. \text{ mm}^4$$

$$y_g = 27.87 \text{ mm}$$

$$T_y = 3150. \text{ N}$$

$$M_x = -2625000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -27.87 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -238.9 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

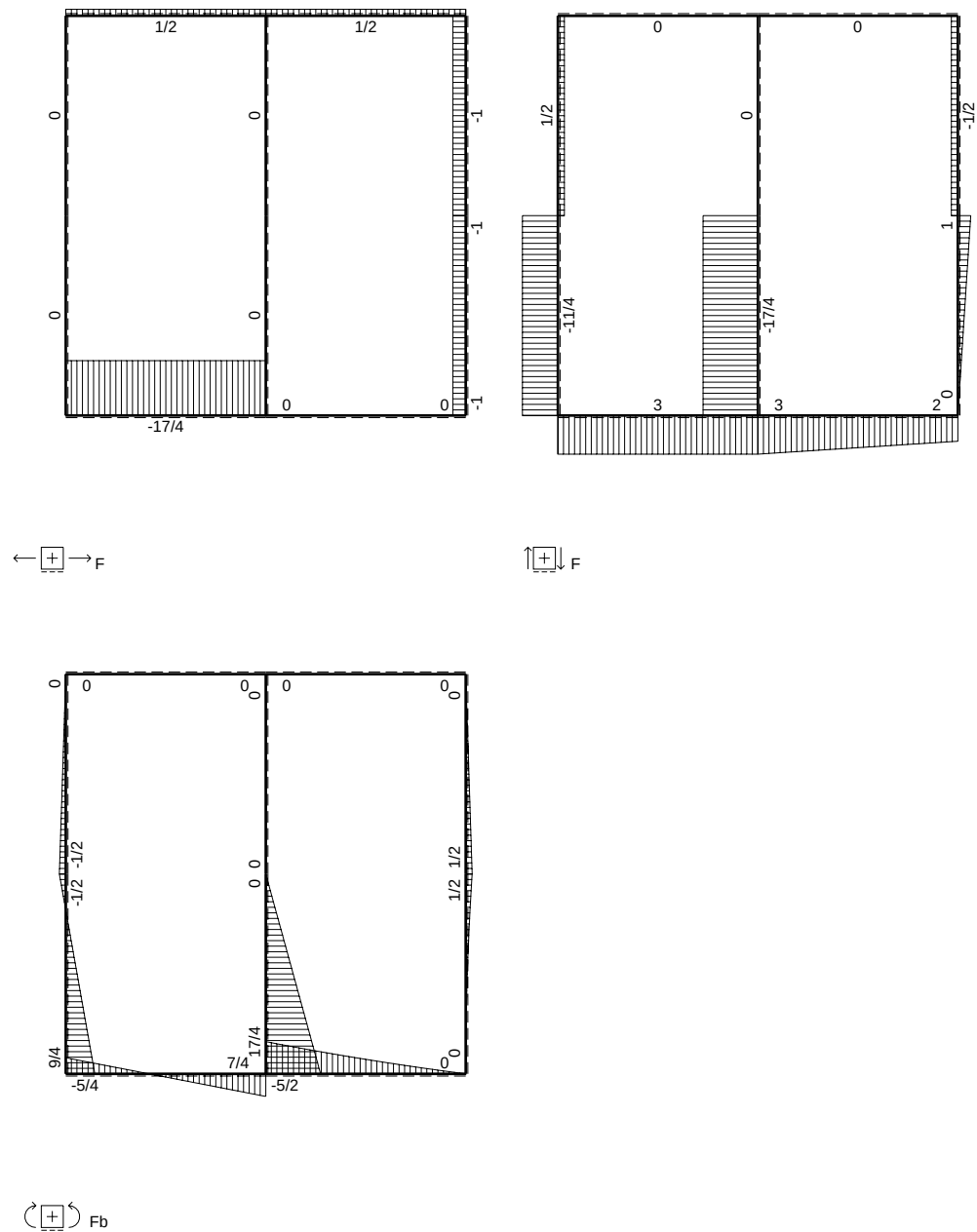
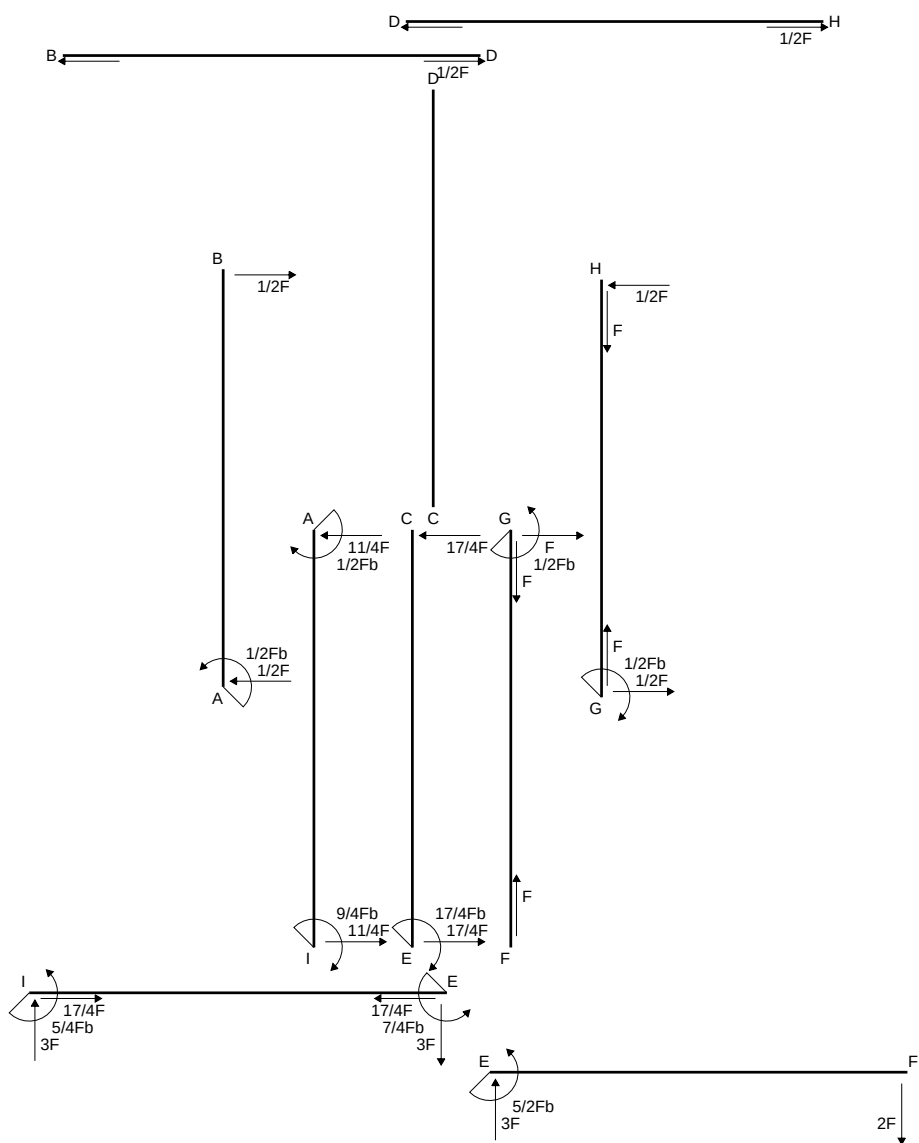
$$v_c = -14.87 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -127.5 \text{ N/mm}^2$$

$$\tau_c = 5.558 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 127.8 \text{ N/mm}^2$$

$$S = 6483. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

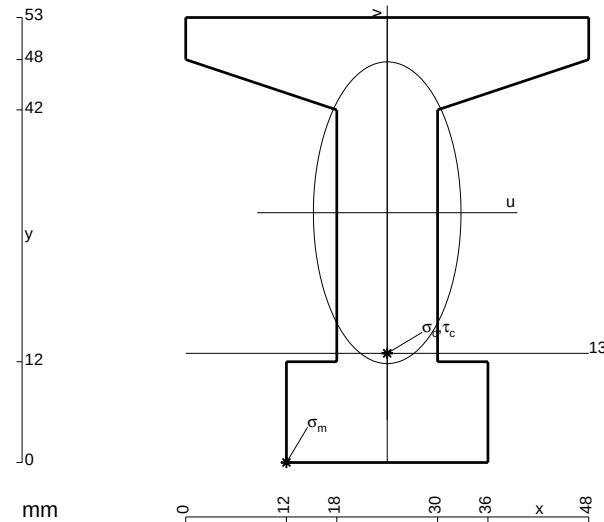
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 1068. \text{ mm}^2$$

$$J_u = 345159. \text{ mm}^4$$

$$J_v = 82584. \text{ mm}^4$$

$$y_g = 29.75 \text{ mm}$$

$$T_y = 5250. \text{ N}$$

$$M_x = -2318750. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.75 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

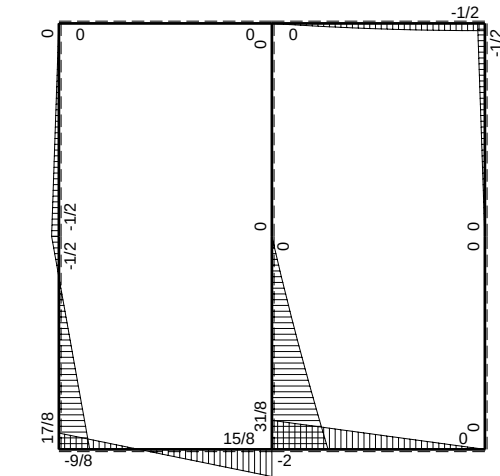
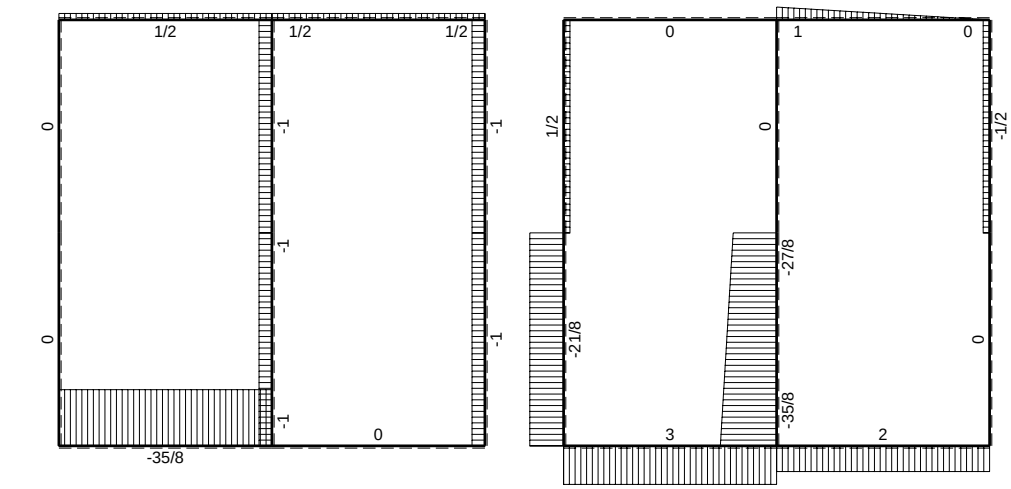
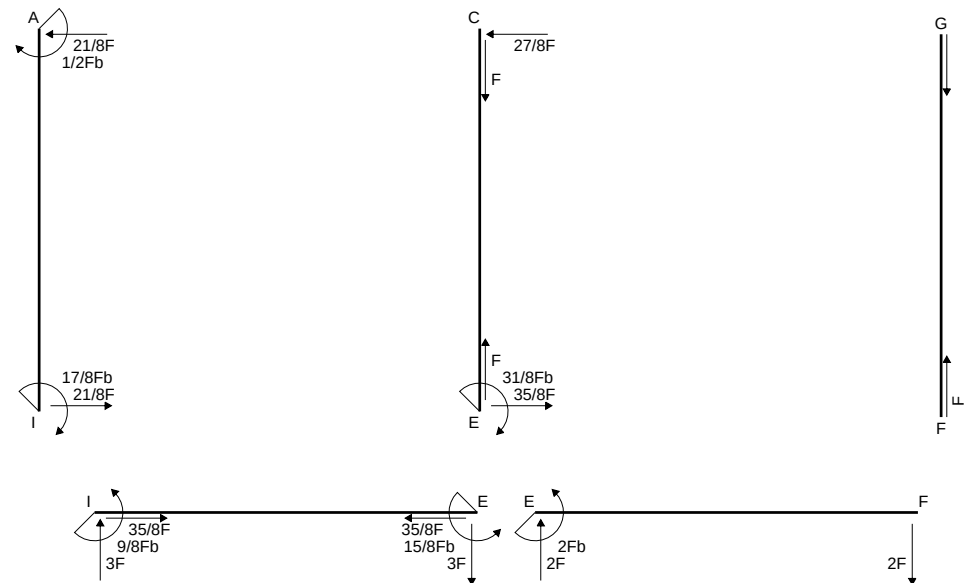
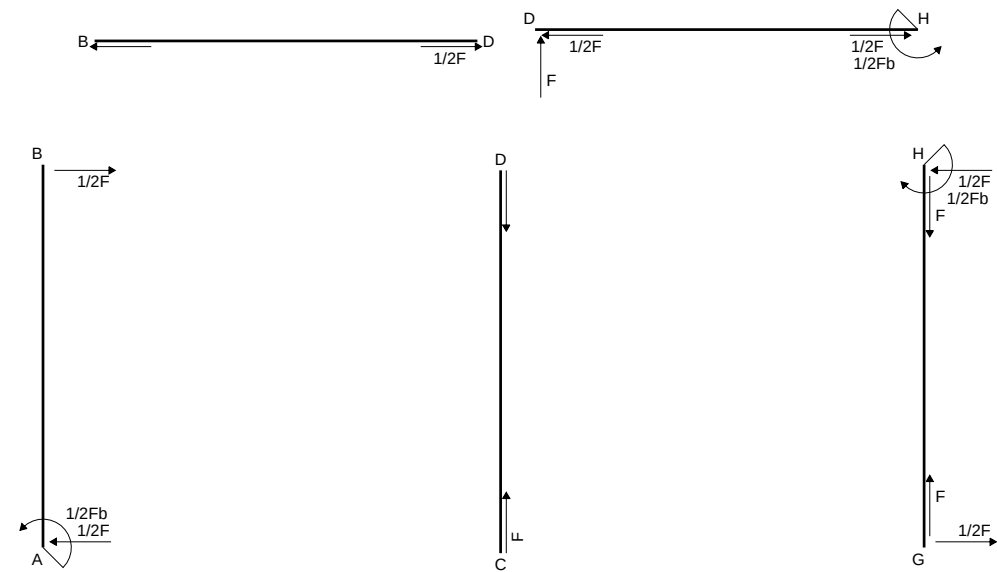
$$v_c = -16.75 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -112.5 \text{ N/mm}^2$$

$$\tau_c = 8.933 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 113.6 \text{ N/mm}^2$$

$$S = 7048. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-11/2Fx+1/2qx^2$	0	$-5Fb+21/2Fx-6Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-13/8+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx-1/2qx^2$	0	$-9/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-15/8Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 6x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-5x + 21/4 x^2/b - 2x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 21/4 b - 2b + 1/8 b) Fb \frac{1}{EJ} = -13/8 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

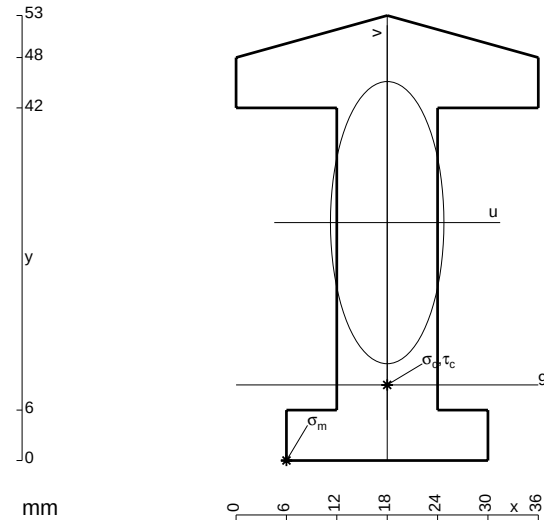
$$= (-3/2 b - 1/8 b) Fb \frac{1}{EJ} = -13/8 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 882. \text{ mm}^2$$

$$J_u = 249349. \text{ mm}^4$$

$$J_v = 40284. \text{ mm}^4$$

$$y_g = 28.33 \text{ mm}$$

$$T_y = 3180. \text{ N}$$

$$M_x = -1844400. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.33 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

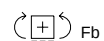
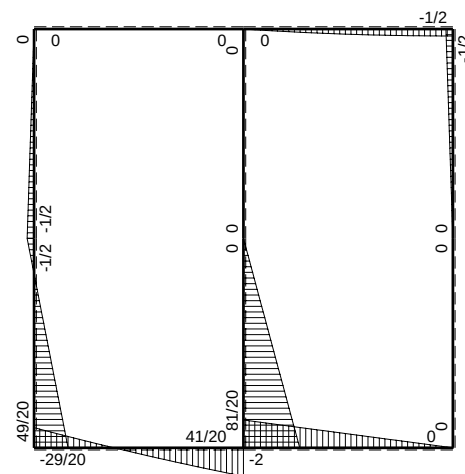
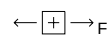
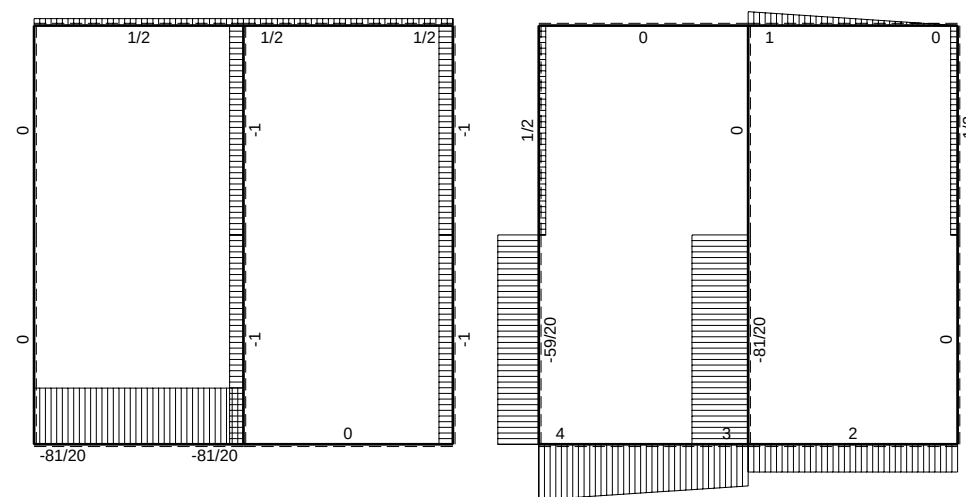
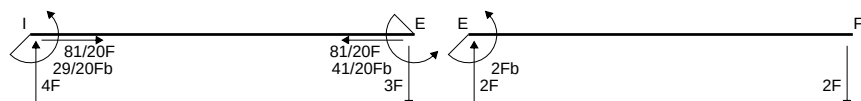
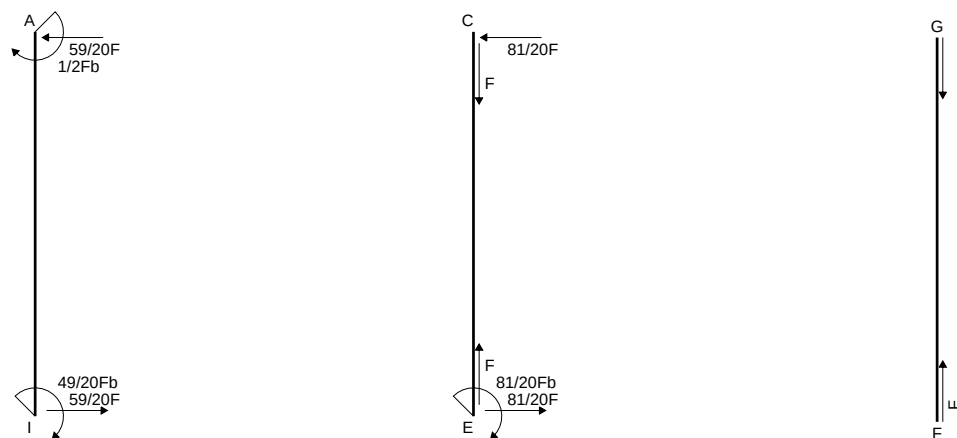
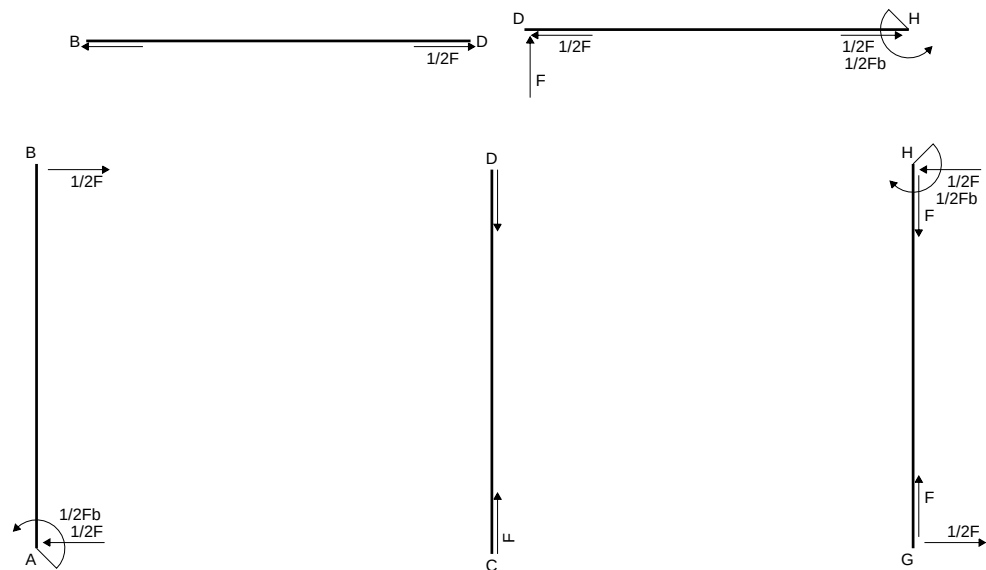
$$v_c = -19.33 \text{ mm}$$

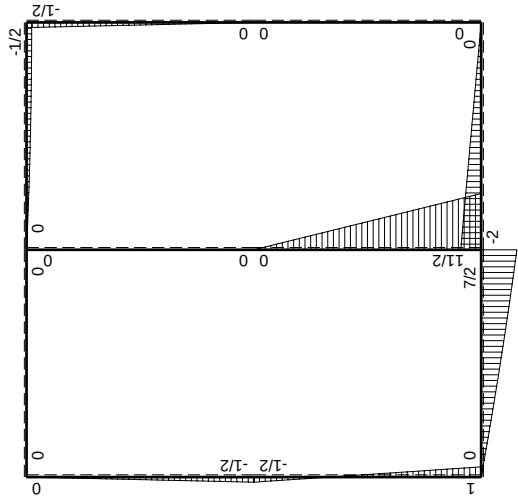
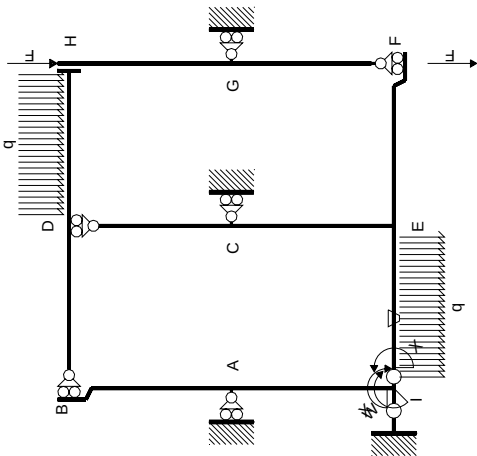
$$\sigma_c = -Mv/J_u = -143. \text{ N/mm}^2$$

$$\tau_c = 4.674 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 143.2 \text{ N/mm}^2$$

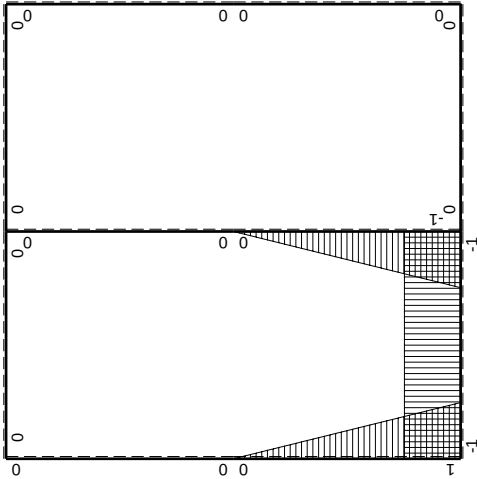
$$S = 4398. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

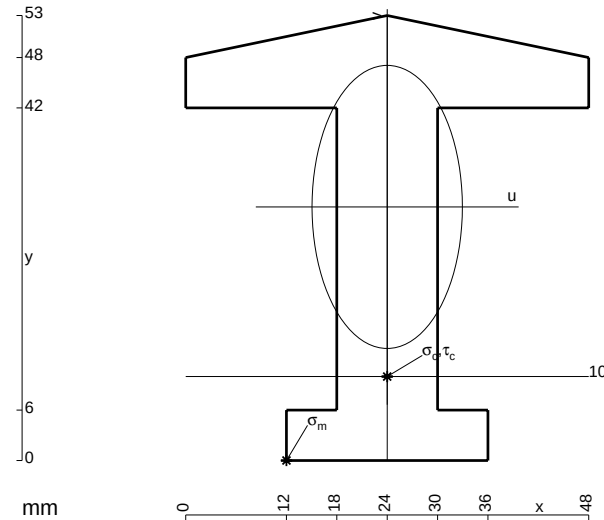
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 984. \text{ mm}^2$$

$$J_u = 279819. \text{ mm}^4$$

$$J_v = 78912. \text{ mm}^4$$

$$y_g = 30.2 \text{ mm}$$

$$T_y = 3220. \text{ N}$$

$$M_x = -2028600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.2 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

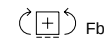
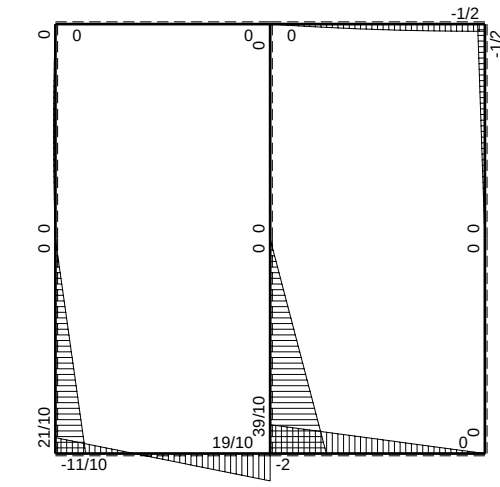
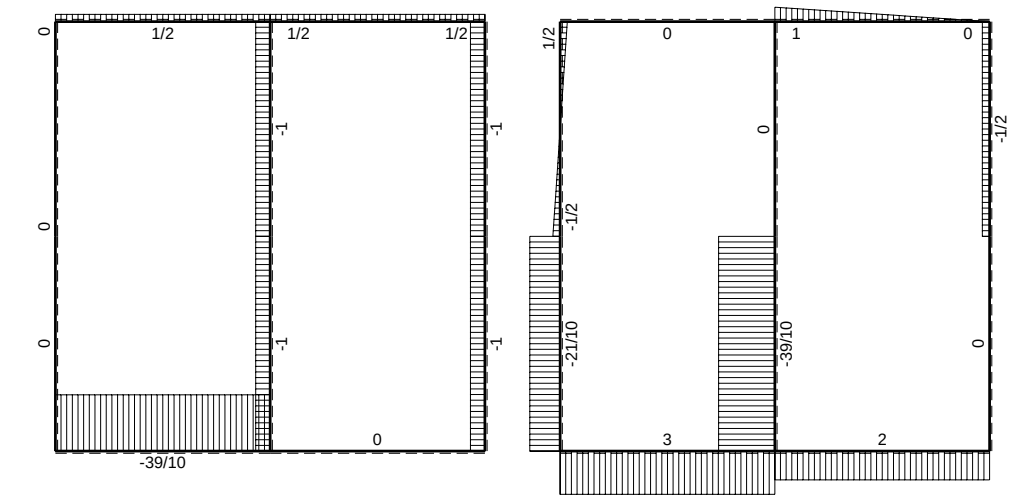
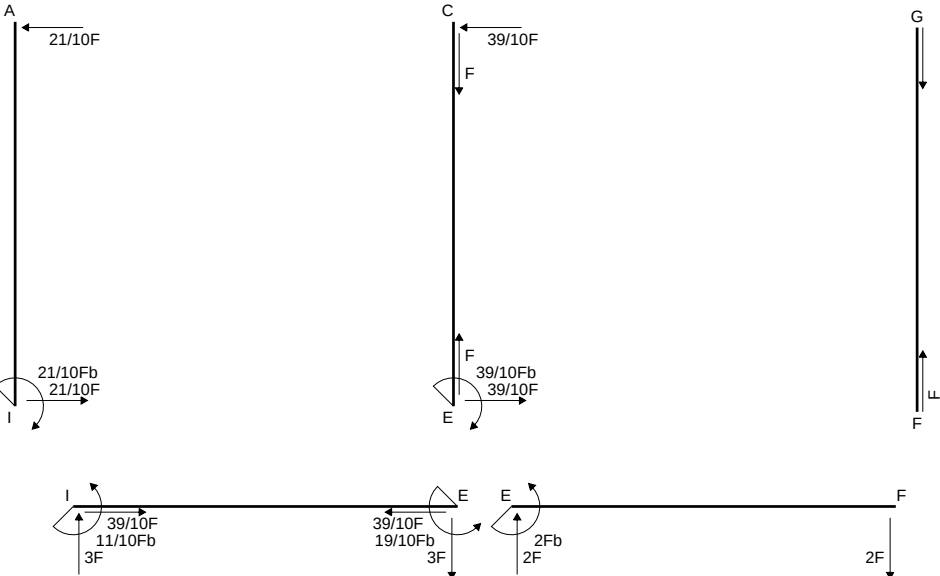
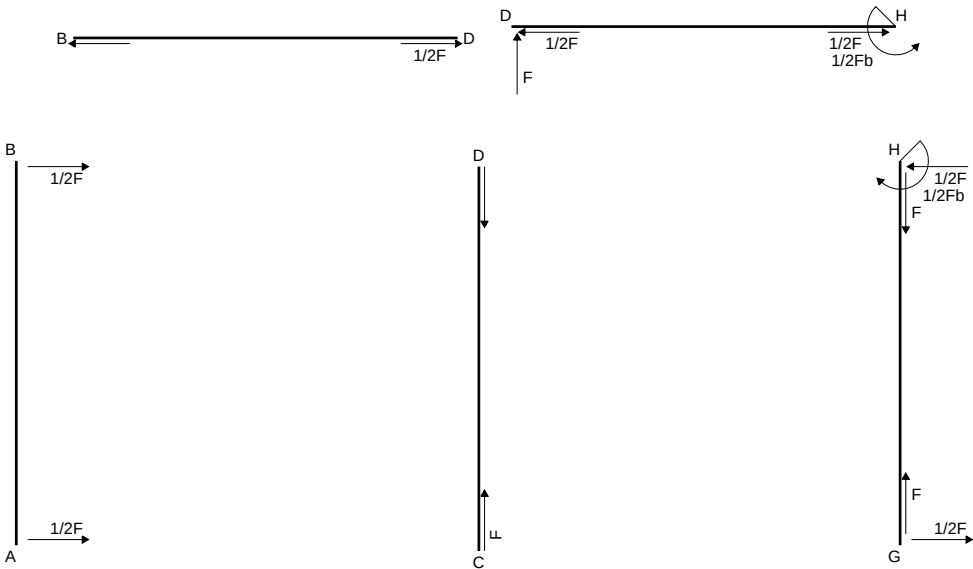
$$v_c = -20.2 \text{ mm}$$

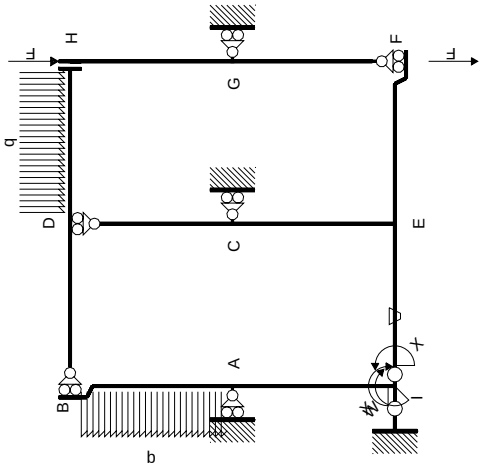
$$\sigma_c = -Mv/J_u = -146.5 \text{ N/mm}^2$$

$$\tau_c = 4.778 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 146.7 \text{ N/mm}^2$$

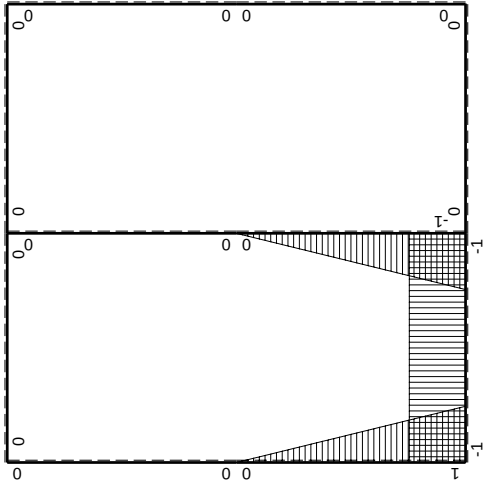
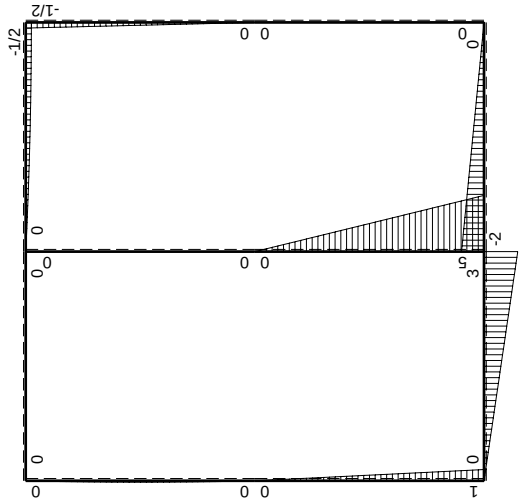
$$S = 4983. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

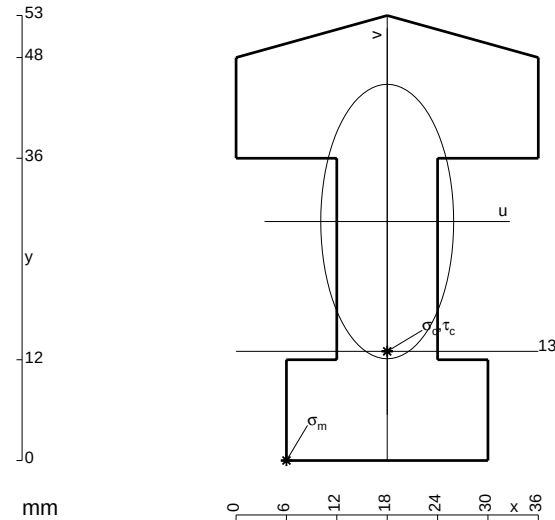
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

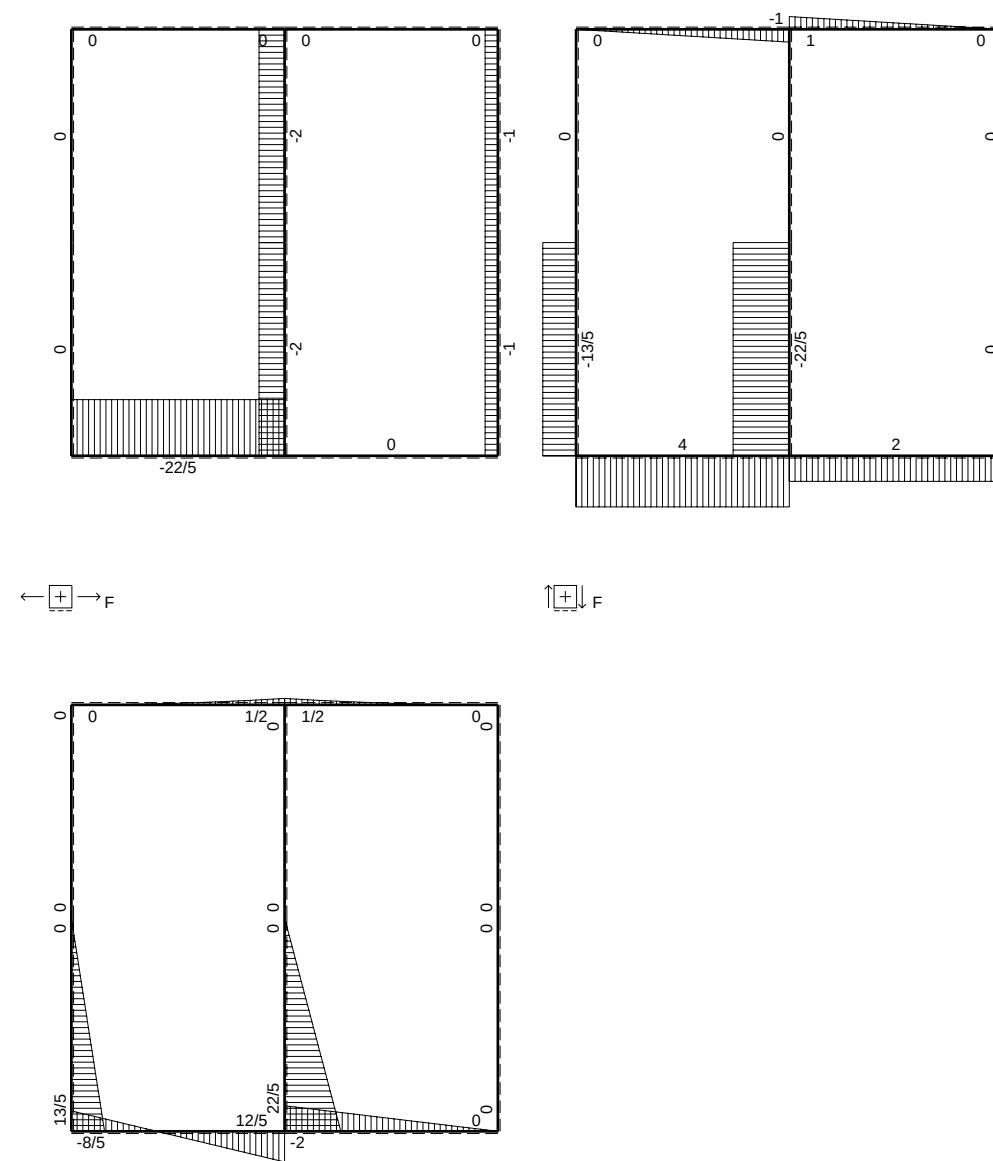
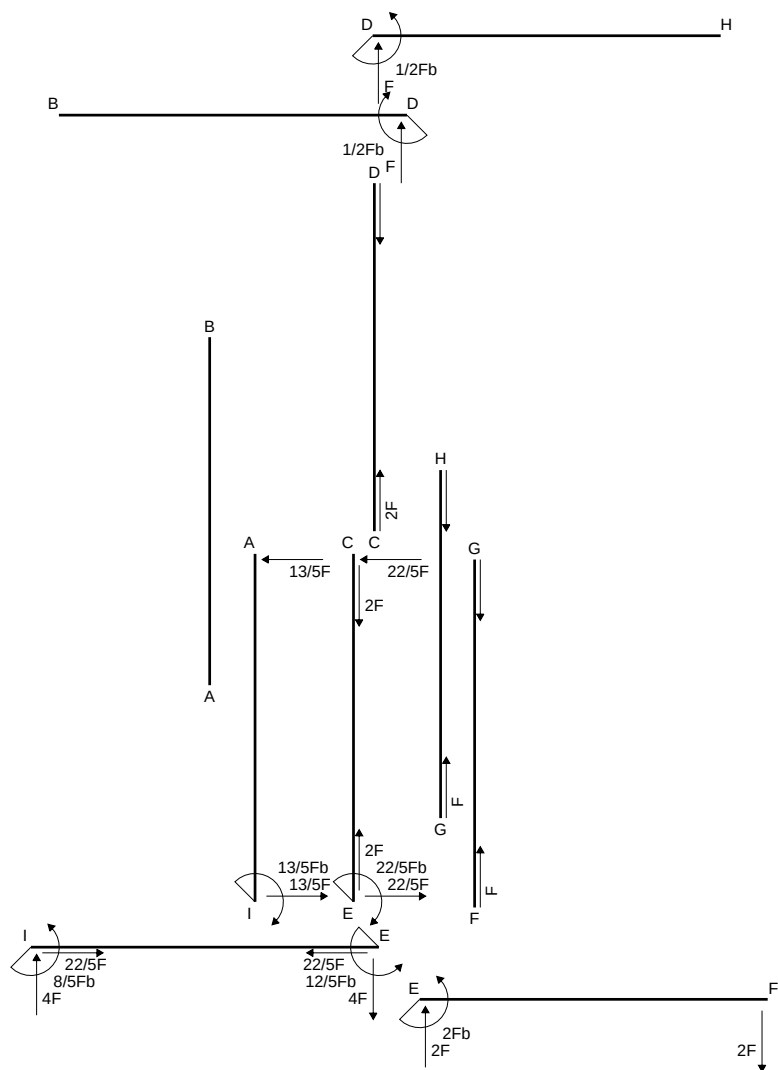
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

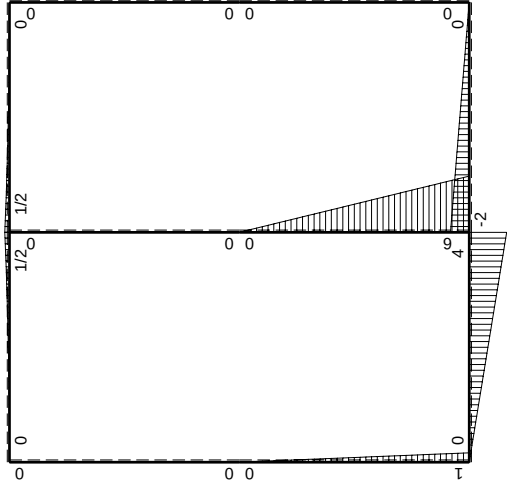
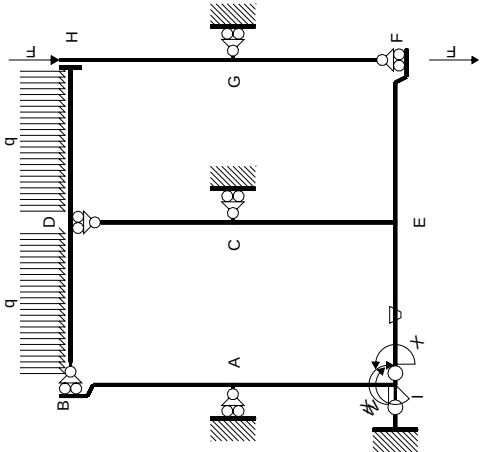
$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$



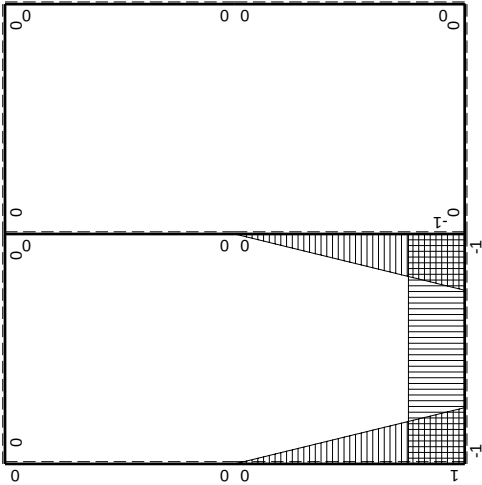
$$\begin{aligned} A &= 1098. \text{ mm}^2 \\ J_u &= 293274. \text{ mm}^4 \\ J_v &= 68796. \text{ mm}^4 \\ y_g &= 28.46 \text{ mm} \\ T_y &= 3480. \text{ N} \\ M_x &= -2366400. \text{ Nmm} \\ x_m &= 6. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -28.46 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.7 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -15.46 \text{ mm} \\ \sigma_c &= -Mv/J_u = -124.8 \text{ N/mm}^2 \\ \tau_c &= 6.587 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 125.3 \text{ N/mm}^2 \\ S &= 6661. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

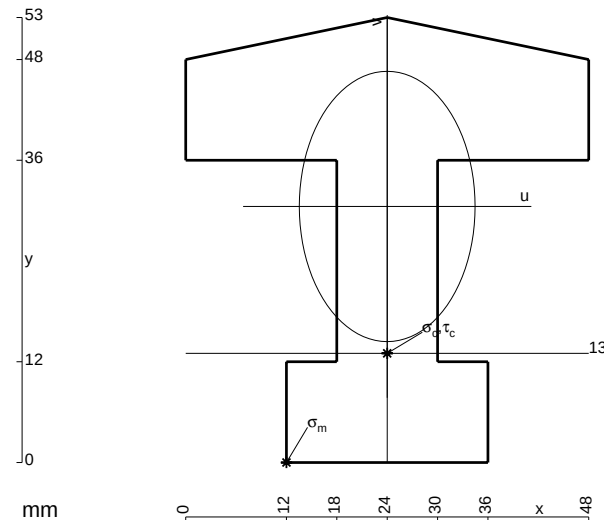
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

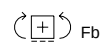
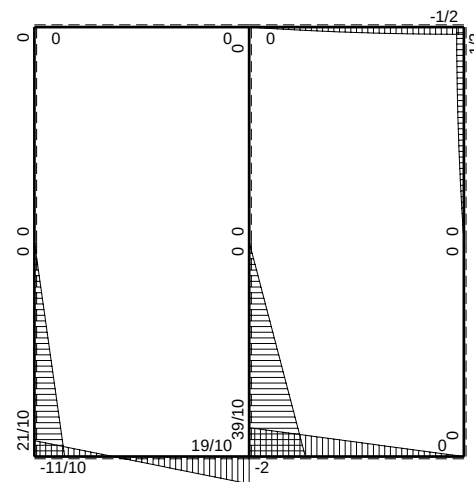
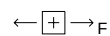
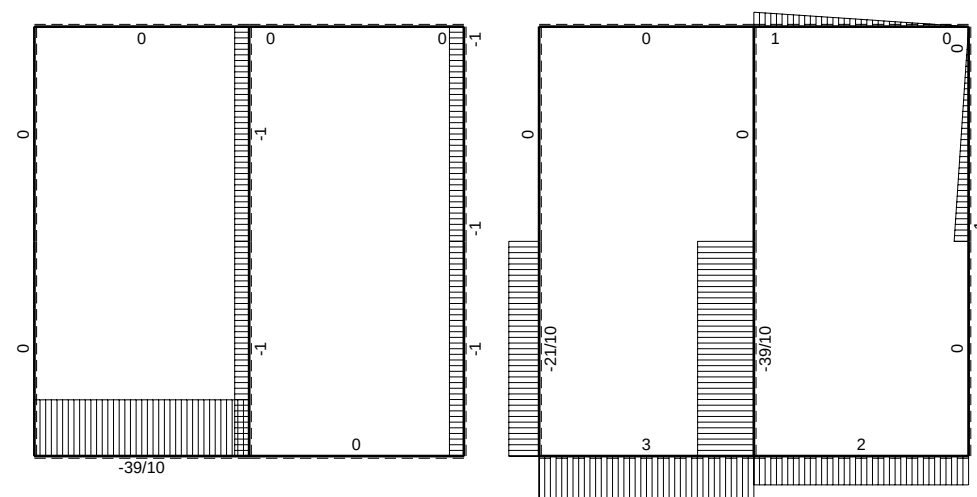
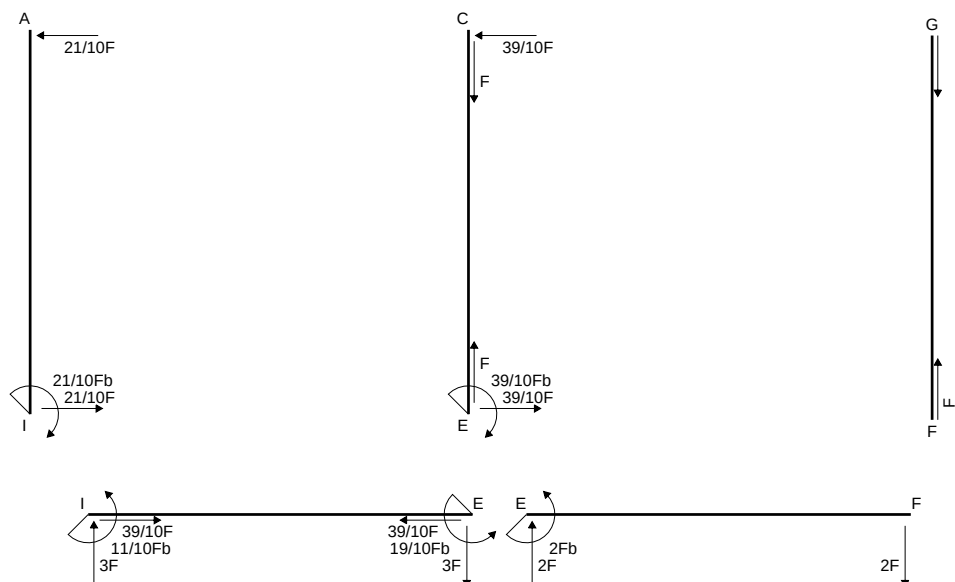
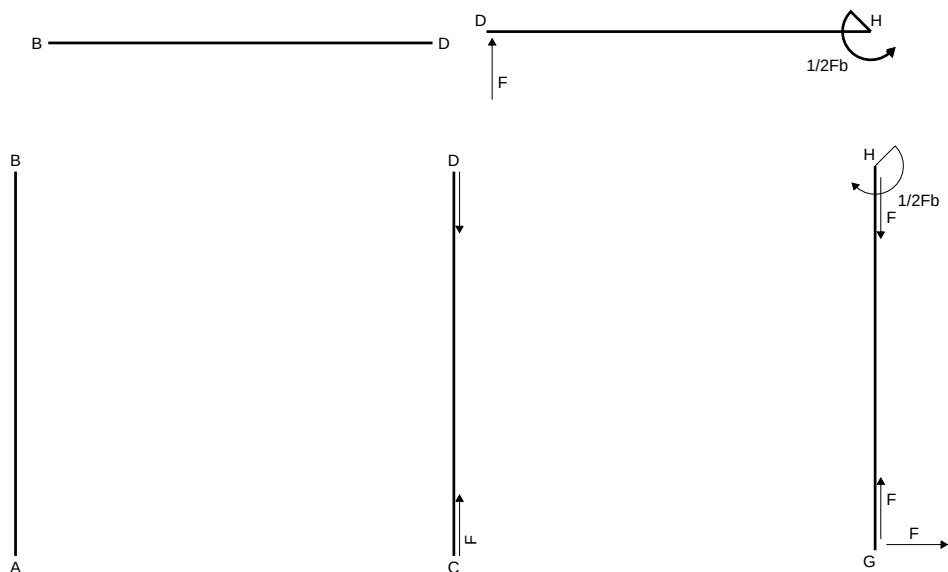
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$



$$\begin{aligned} A &= 1272. \text{ mm}^2 \\ J_u &= 329658. \text{ mm}^4 \\ J_v &= 139392. \text{ mm}^4 \\ y_g &= 30.5 \text{ mm} \\ T_y &= 3500. \text{ N} \\ M_x &= -2590000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.5 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.5 \text{ mm} \\ \sigma_c &= -Mv/J_u = -137.5 \text{ N/mm}^2 \\ \tau_c &= 6.433 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 137.9 \text{ N/mm}^2 \\ S &= 7271. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-Fx+1/2qx ²	0	0	0	0	0+0	0
HG b	0	1/2Fb-1/2qx ²	0	0	0	0		
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0
DH b	0	Fx-1/2qx ²	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	-1+x/b	5Fb-5Fx	0	-5Fb+10Fx-5Fx ² /b	0	1-2x/b+x ² /b ²	(-5/3+0)Fb ² /EJ	1/3Xb/EJ
CE b	x/b	-5Fx	0	-5Fx ² /b	0	x ² /b ²		
IA b	1-x/b	Fb-Fx	0	Fb-2Fx+Fx ² /b	0	1-2x/b+x ² /b ²	(1/3+0)Fb ² /EJ	1/3Xb/EJ
AI b	-x/b	-Fx	0	Fx ² /b	0	x ² /b ²		
	totali						-11/6Fb ² /EJ	5/3Xb/EJ
	iperstatica $X=W_{IE}$						11/10Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

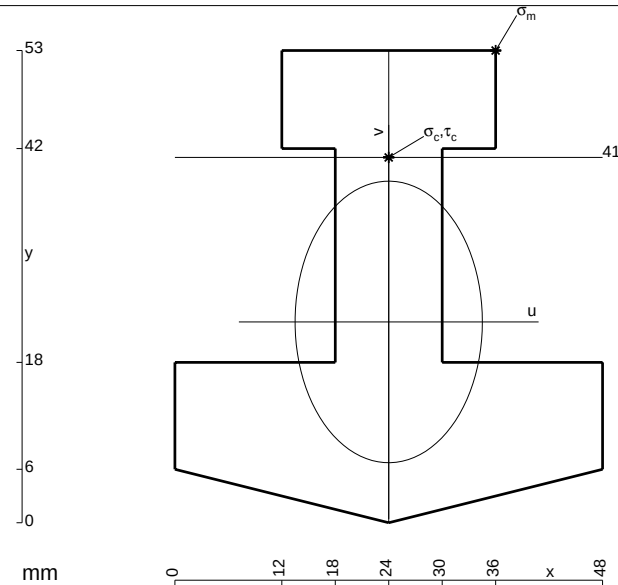
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

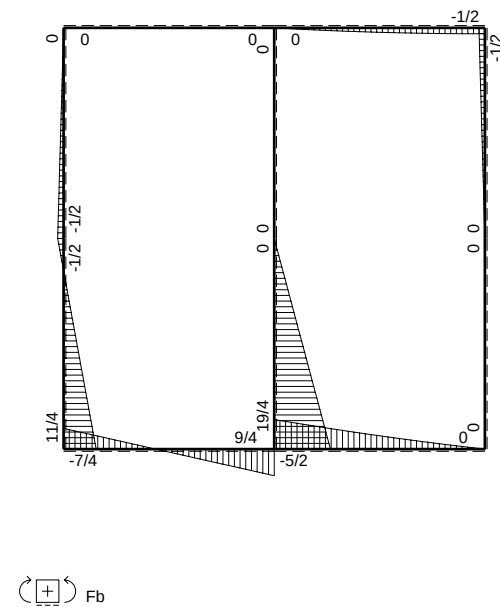
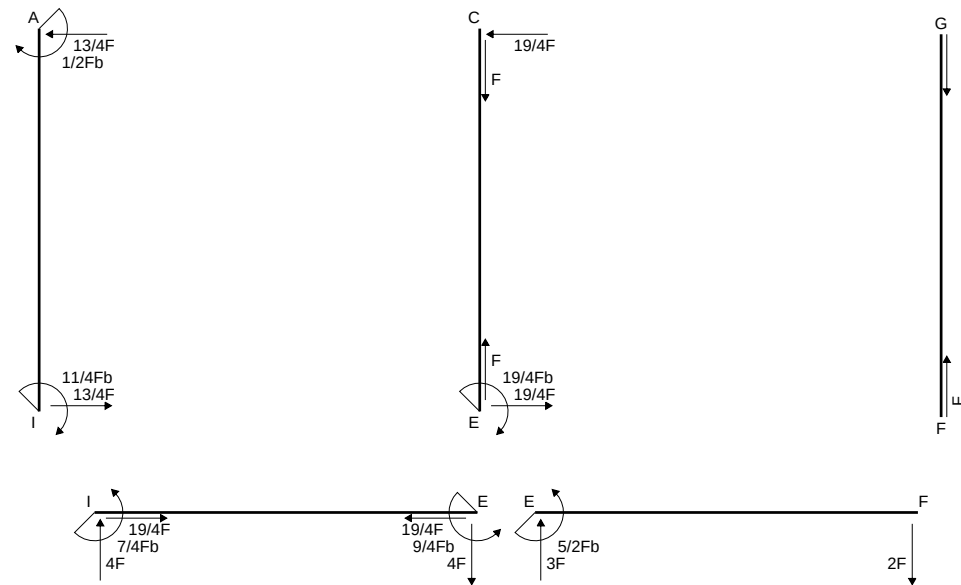
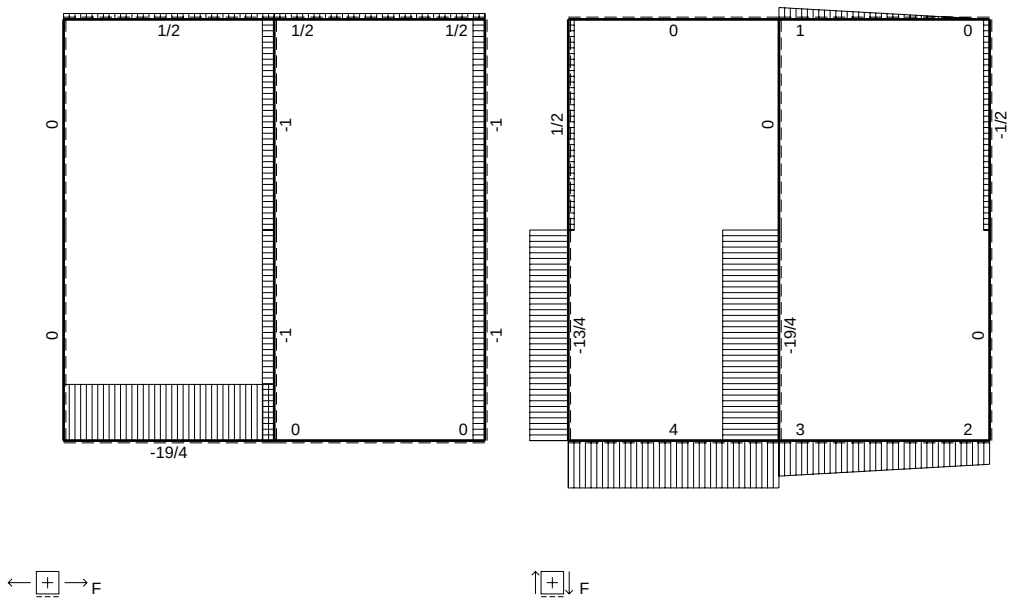
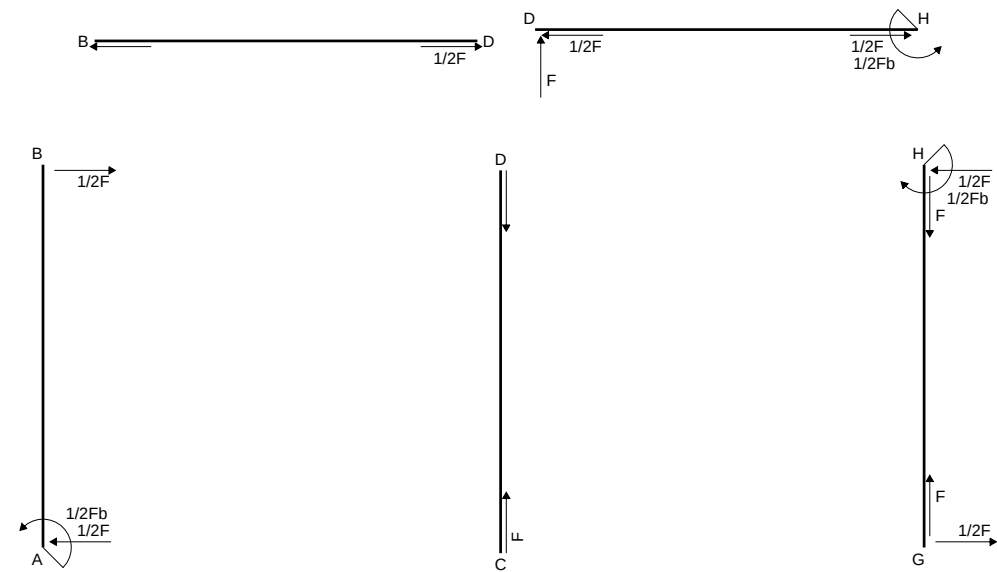
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

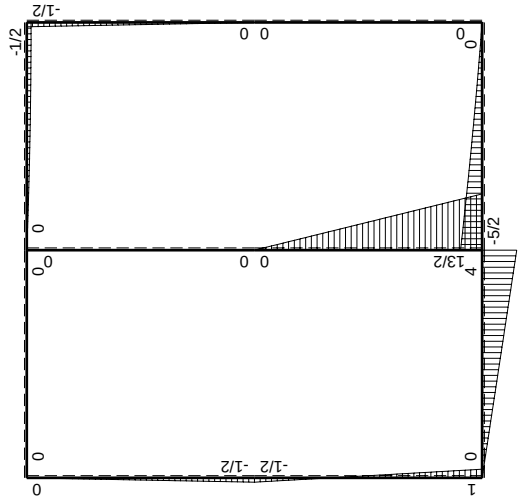
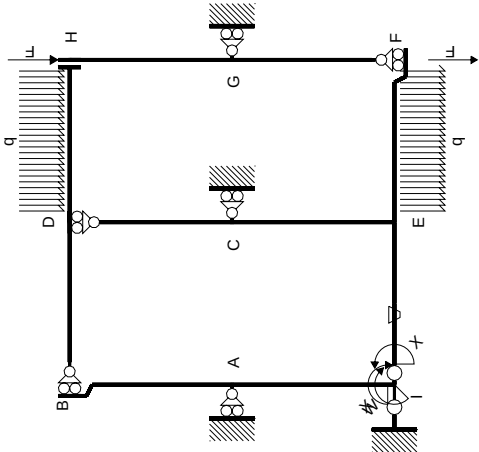
$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$



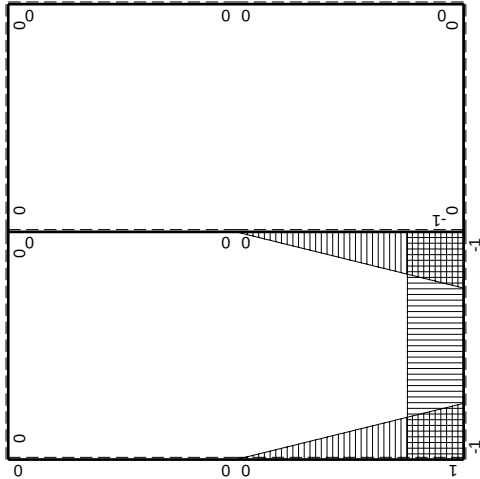
$$\begin{aligned} A &= 1272. \text{ mm}^2 \\ J_u &= 317672. \text{ mm}^4 \\ J_v &= 140544. \text{ mm}^4 \\ y_g &= 22.54 \text{ mm} \\ T_y &= 2640. \text{ N} \\ M_x &= -2085600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.46 \text{ mm} \\ \sigma_m &= -Mv/J_u = 200. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 18.46 \text{ mm} \\ \sigma_c &= -Mv/J_u = 121.2 \text{ N/mm}^2 \\ \tau_c &= 4.721 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 121.5 \text{ N/mm}^2 \\ S &= 6818. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

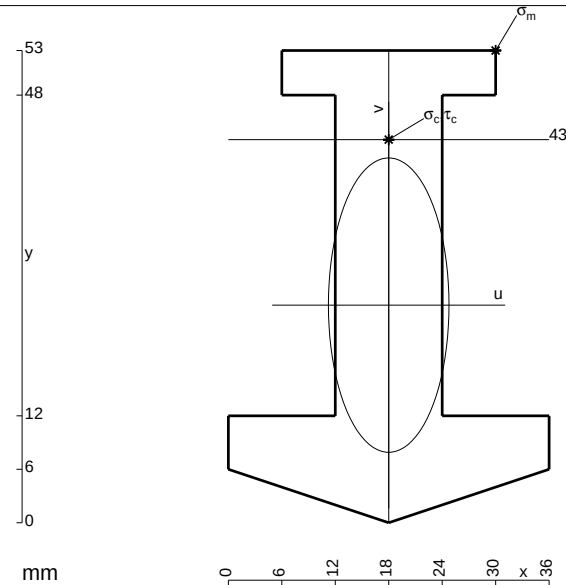
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 876. \text{ mm}^2$$

$$J_u = 239234. \text{ mm}^4$$

$$J_v = 40104. \text{ mm}^4$$

$$y_g = 24.42 \text{ mm}$$

$$T_y = 2490. \text{ N}$$

$$M_x = -1743000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.58 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.2 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

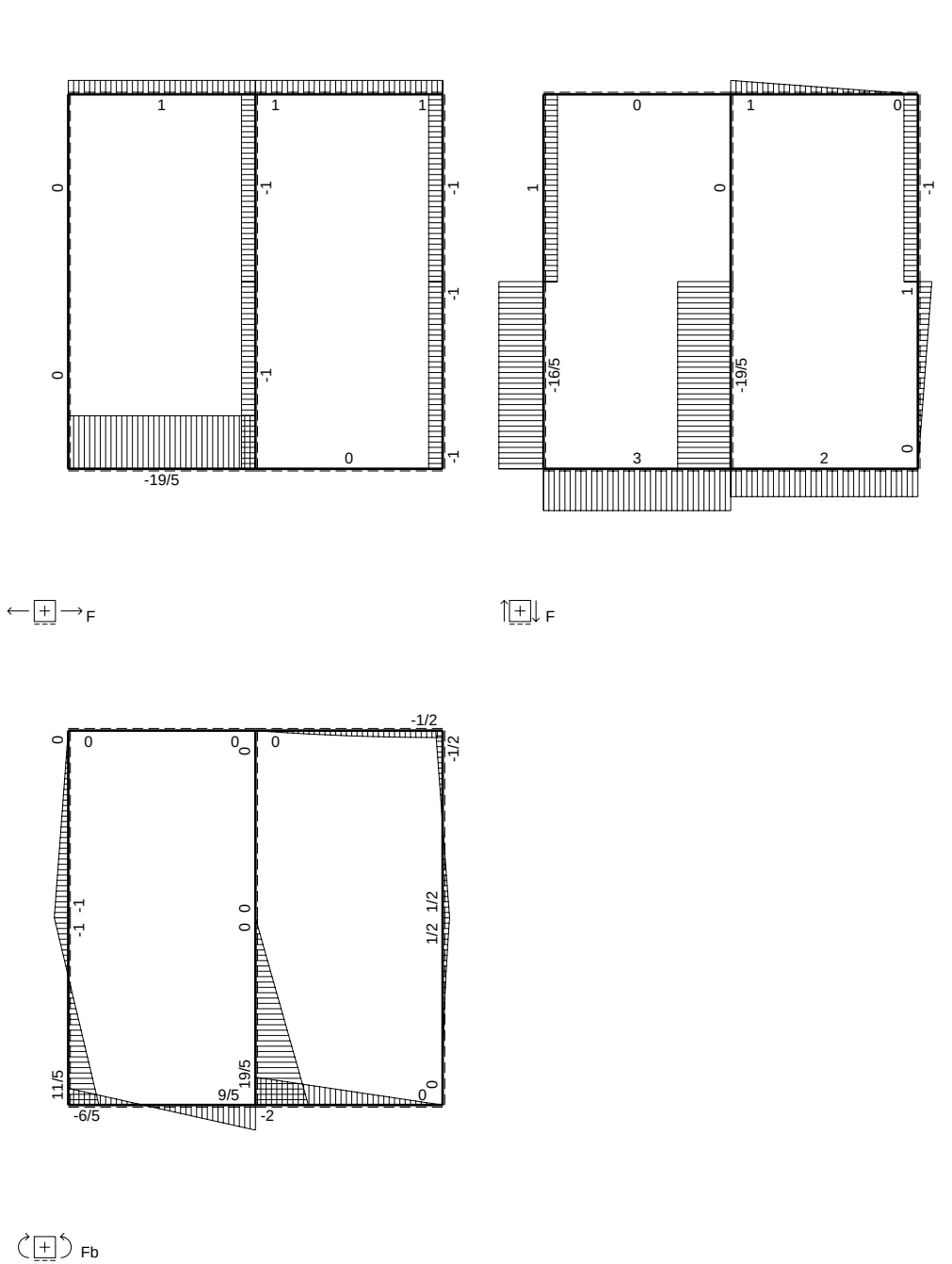
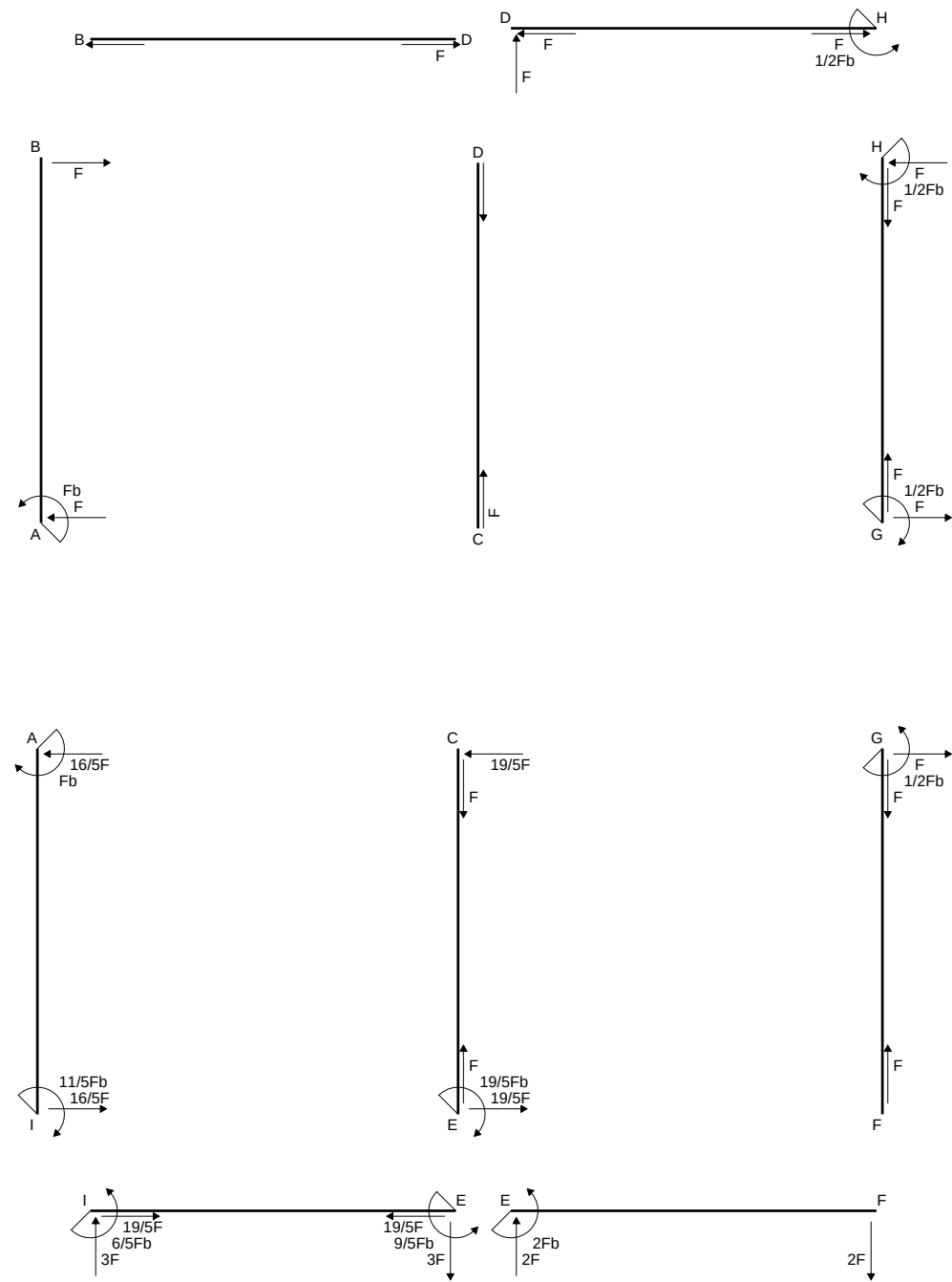
$$v_c = 18.58 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 135.3 \text{ N/mm}^2$$

$$\tau_c = 3.811 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 135.5 \text{ N/mm}^2$$

$$S = 4394. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-2Fx$	0	$Fb-3Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-2Fx$	0	$-Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

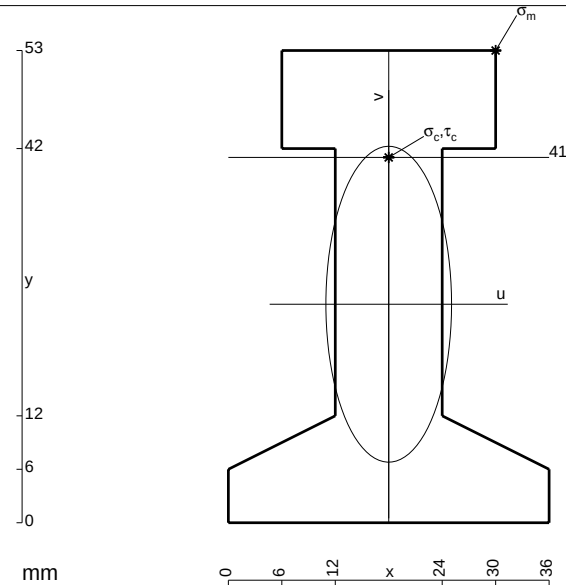
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/2 x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/2 b + 2/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 2/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 984. \text{ mm}^2$$

$$J_u = 309321. \text{ mm}^4$$

$$J_v = 48960. \text{ mm}^4$$

$$y_g = 24.52 \text{ mm}$$

$$T_y = 2640. \text{ N}$$

$$M_x = -2376000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.48 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 218.7 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

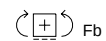
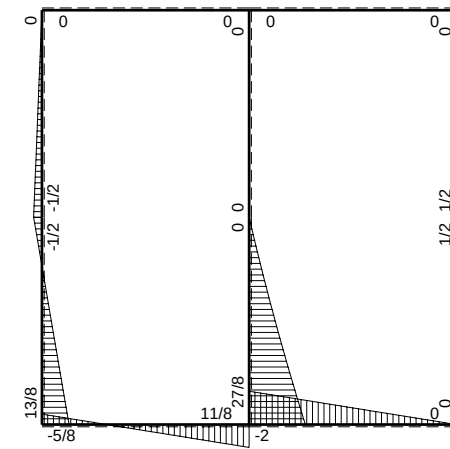
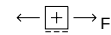
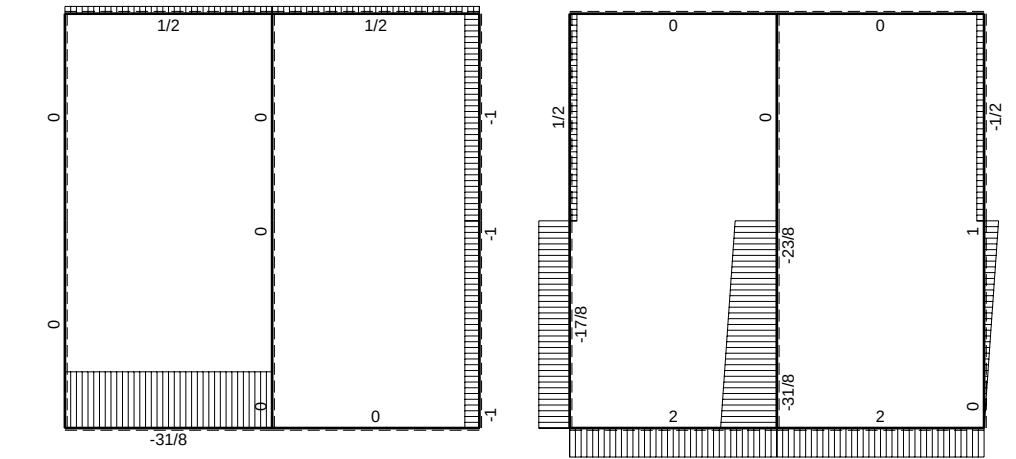
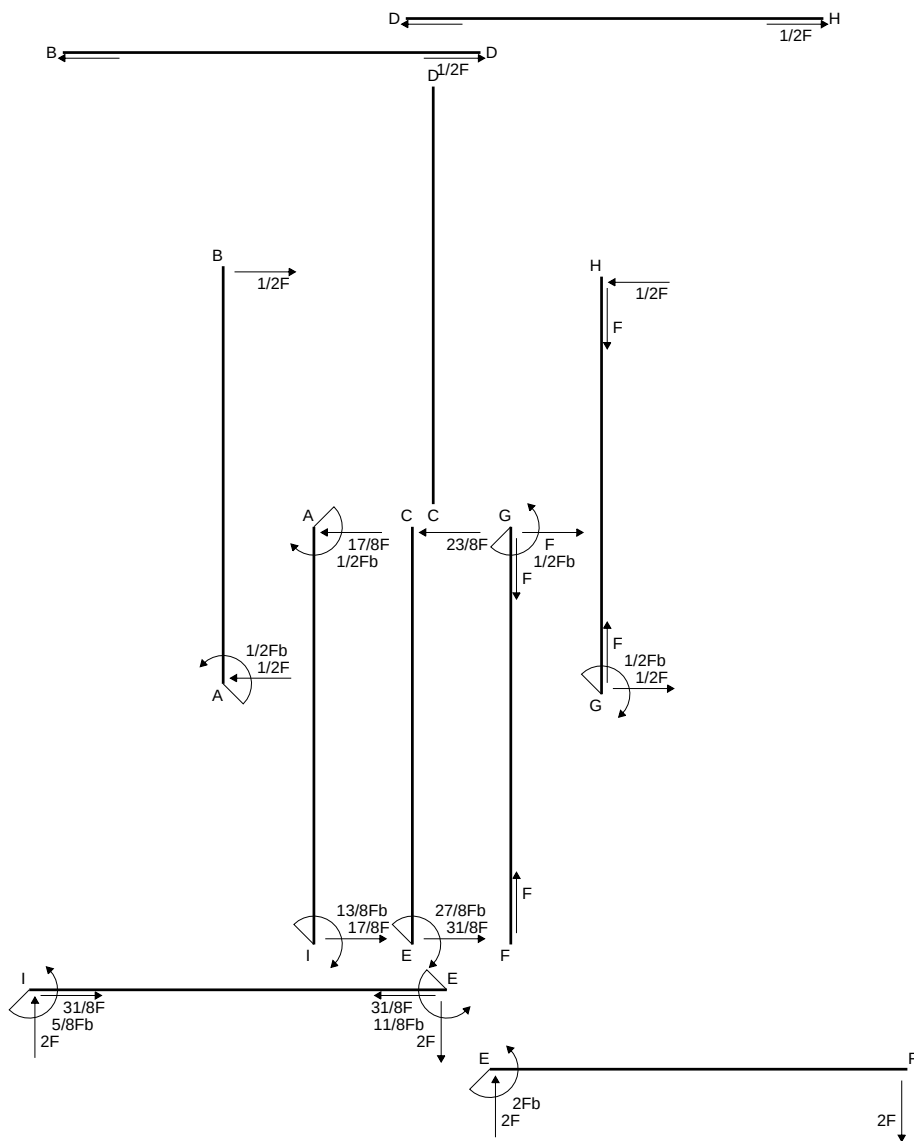
$$v_c = 16.48 \text{ mm}$$

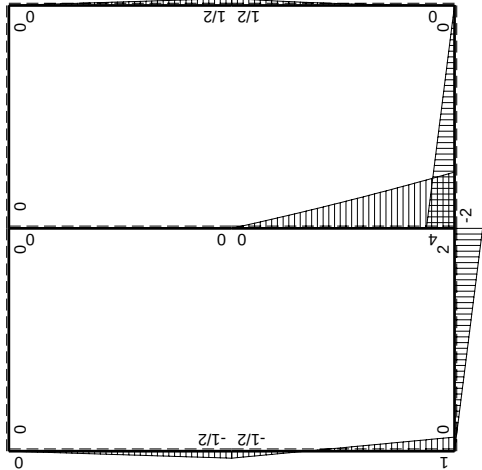
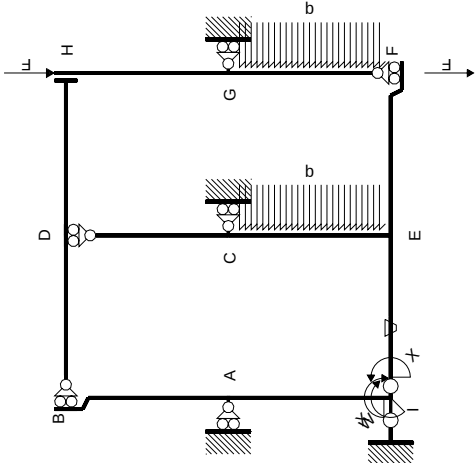
$$\sigma_c = -Mv/J_u = 126.6 \text{ N/mm}^2$$

$$\tau_c = 4.459 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 126.8 \text{ N/mm}^2$$

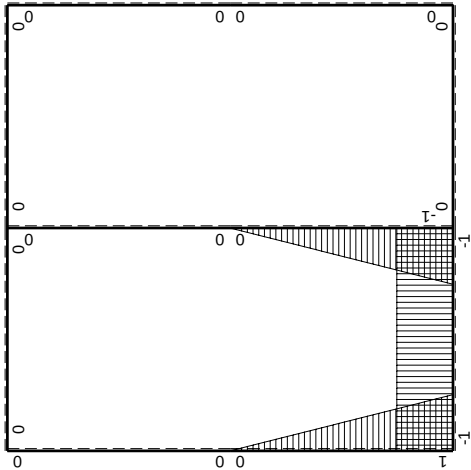
$$S = 6269. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= \left[-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-7/6 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

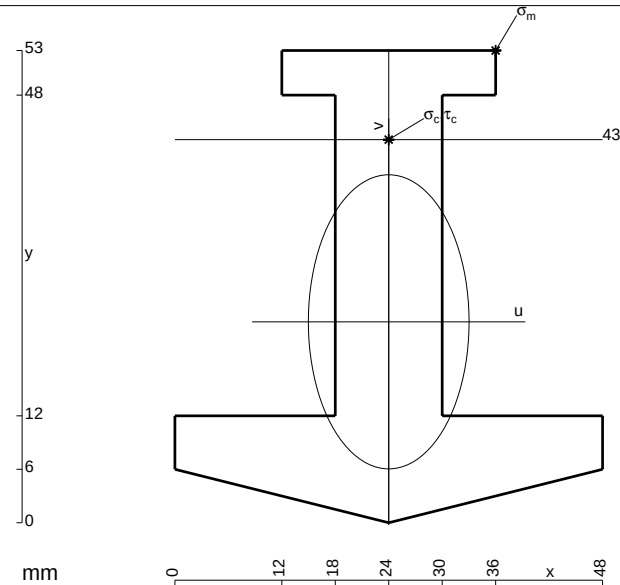
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

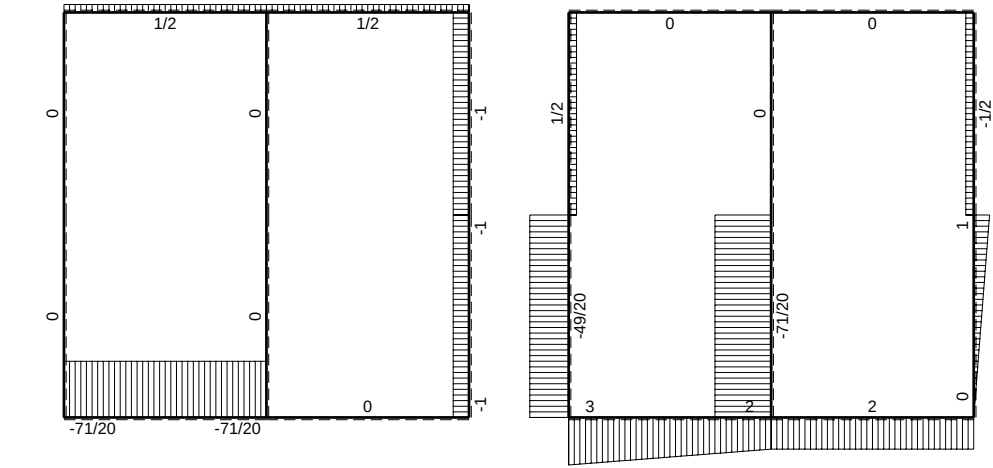
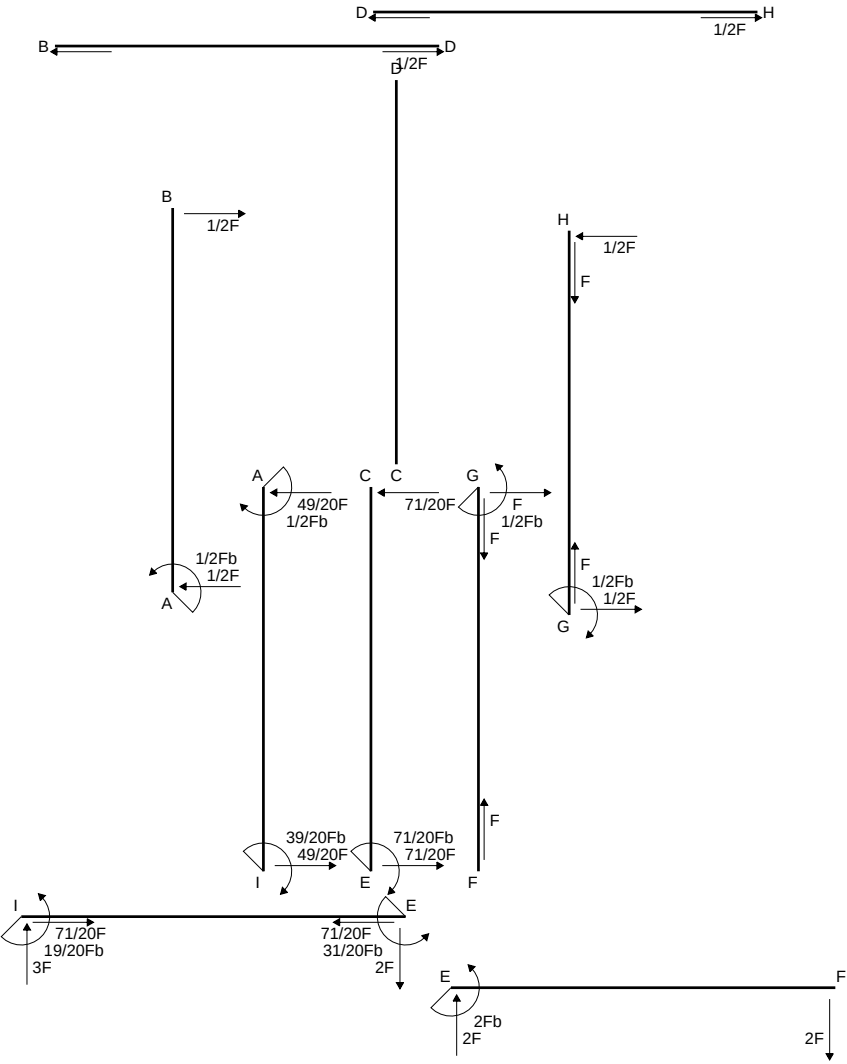
$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

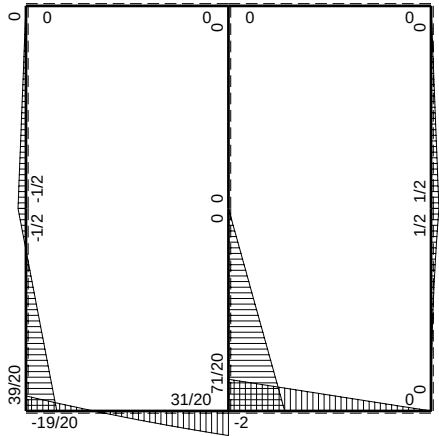


$$\begin{aligned} A &= 984. \text{ mm}^2 \\ J_u &= 268208. \text{ mm}^4 \\ J_v &= 80064. \text{ mm}^4 \\ y_g &= 22.55 \text{ mm} \\ T_y &= 2120. \text{ N} \\ M_x &= -2014000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.45 \text{ mm} \\ \sigma_m &= -Mv/J_u = 228.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 20.45 \text{ mm} \\ \sigma_c &= -Mv/J_u = 153.6 \text{ N/mm}^2 \\ \tau_c &= 3.116 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 153.7 \text{ N/mm}^2 \\ S &= 4731. \text{ mm}^3 \end{aligned}$$

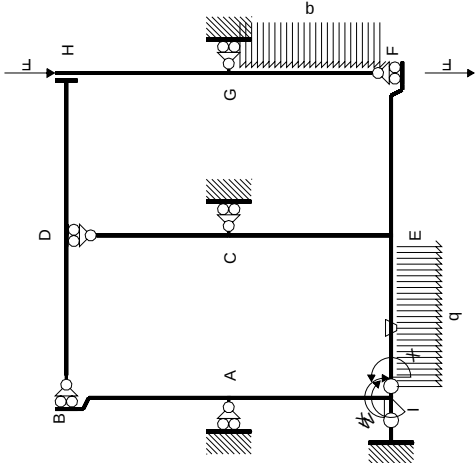


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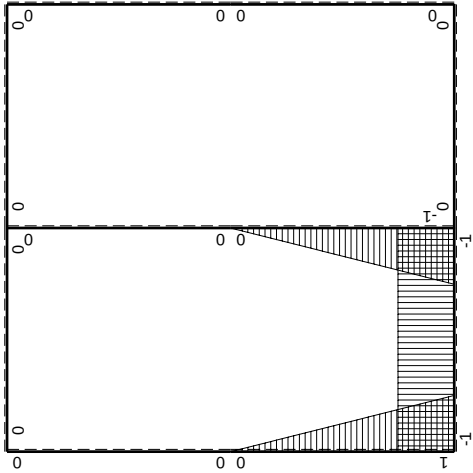
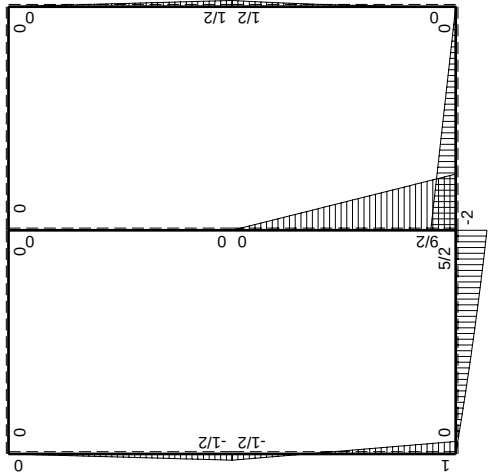


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-19/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

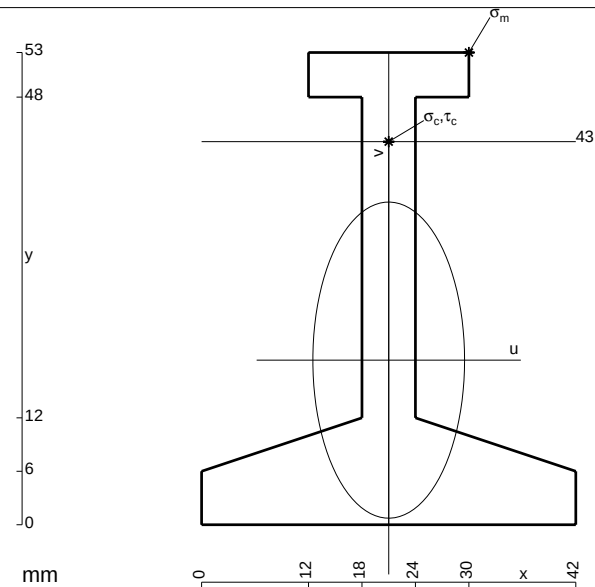
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 702. \text{ mm}^2$$

$$J_u = 221020. \text{ mm}^4$$

$$J_v = 50922. \text{ mm}^4$$

$$y_g = 18.47 \text{ mm}$$

$$T_y = 1520. \text{ N}$$

$$M_x = -1520000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 34.53 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 237.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

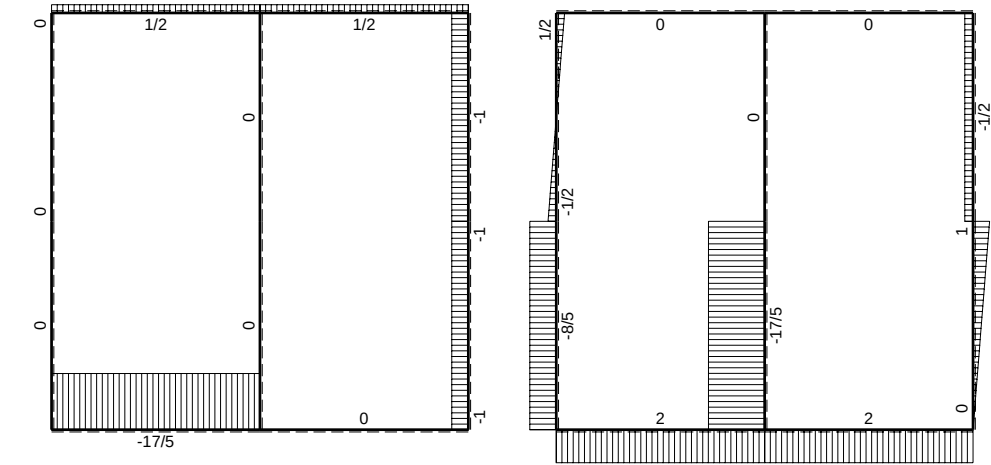
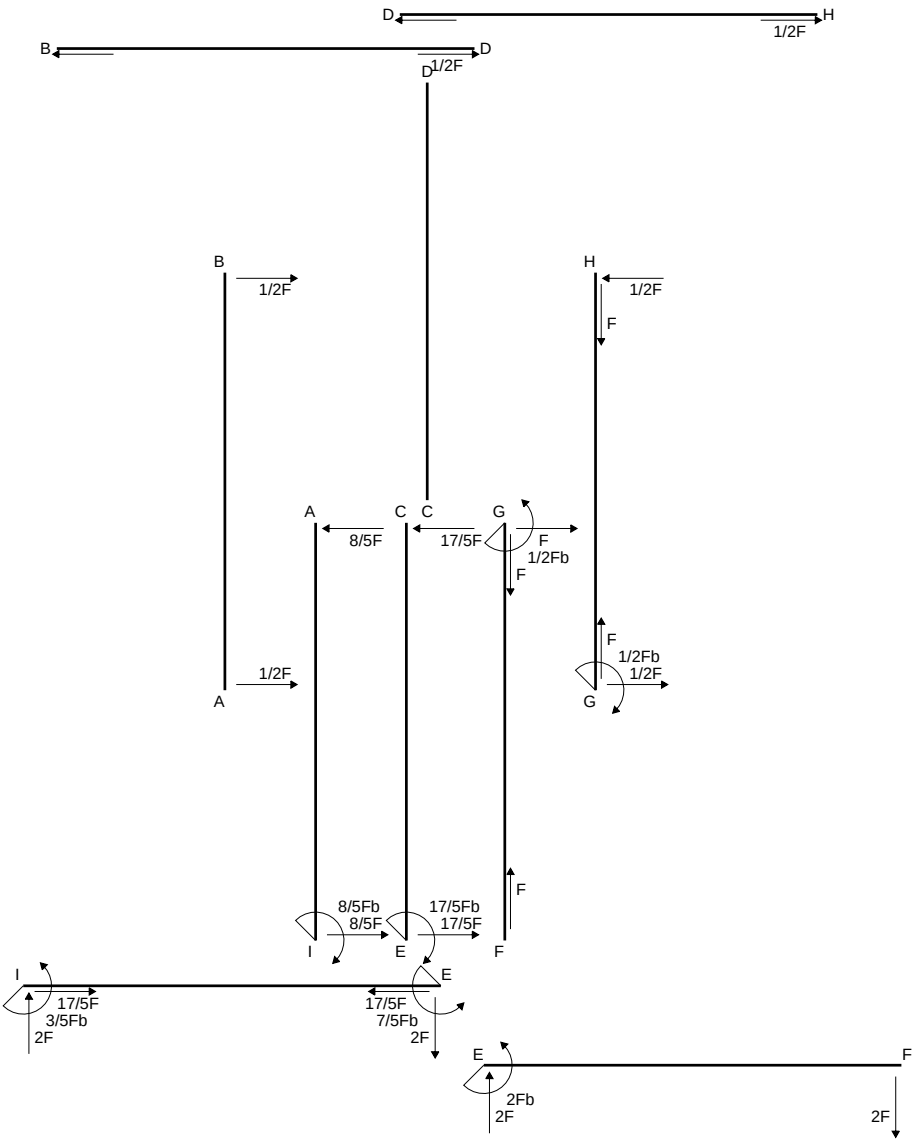
$$v_c = 24.53 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 168.7 \text{ N/mm}^2$$

$$\tau_c = 4.233 \text{ N/mm}^2$$

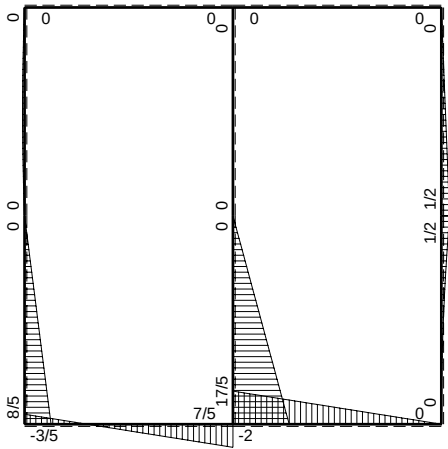
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 168.8 \text{ N/mm}^2$$

$$S = 3693. \text{ mm}^3$$

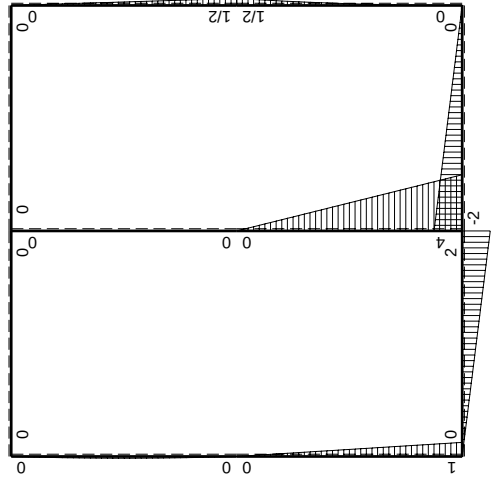
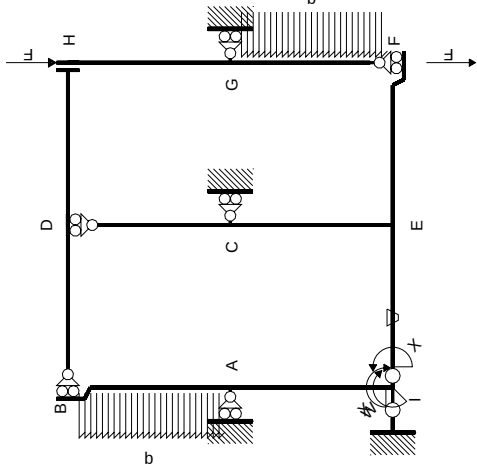


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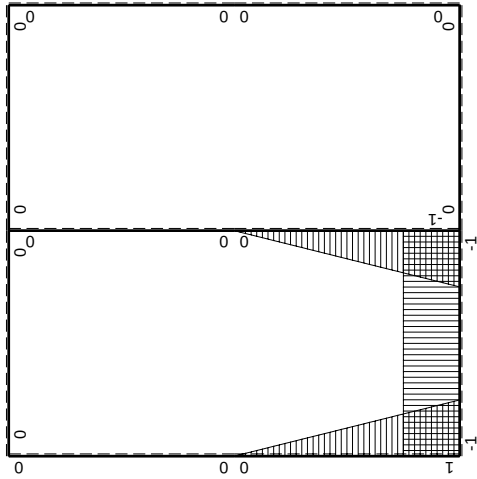


⊕ ⊖ Fb



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

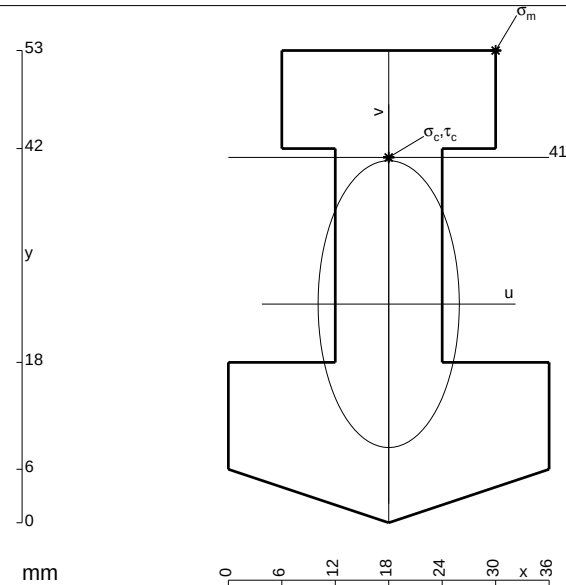
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

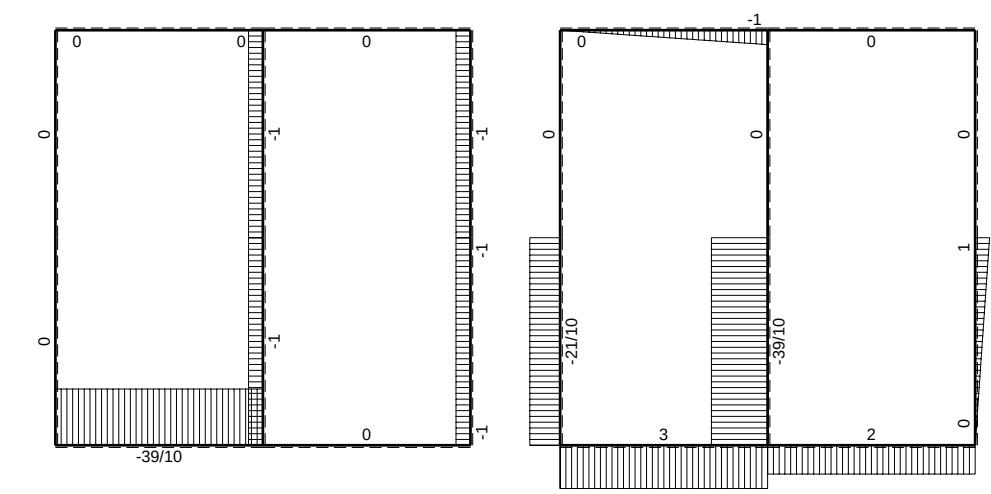
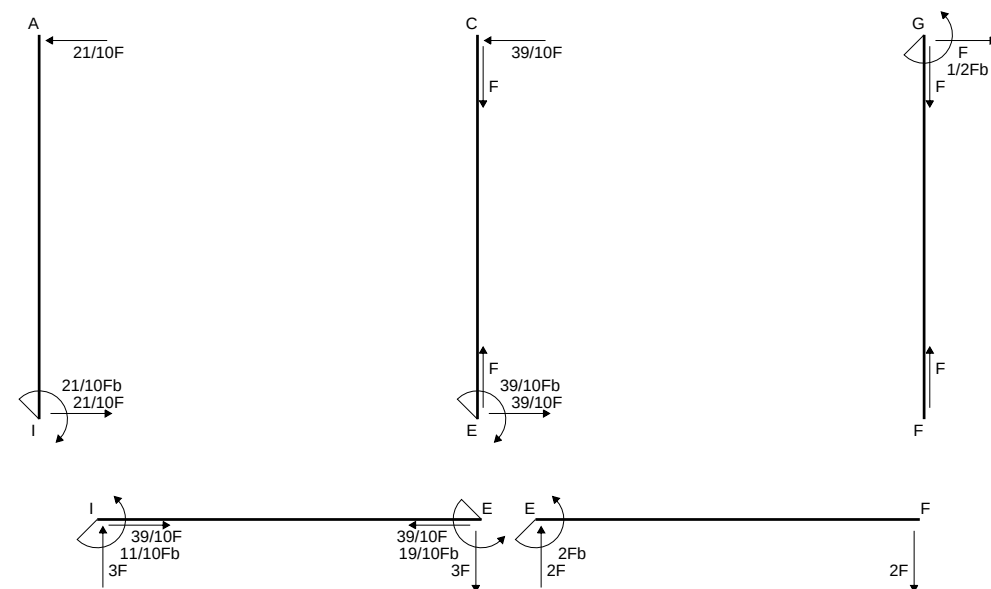
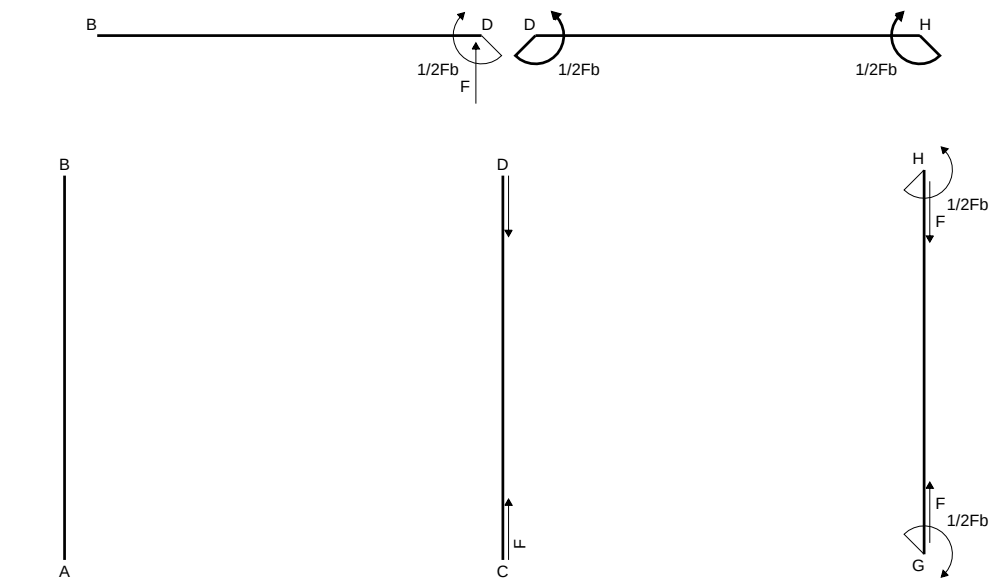
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

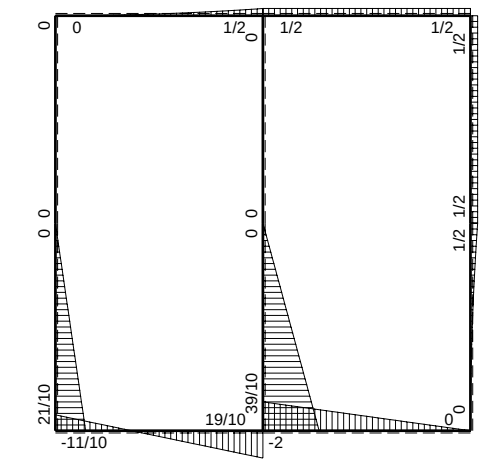


$$\begin{aligned} A &= 1092. \text{ mm}^2 \\ J_u &= 283139. \text{ mm}^4 \\ J_v &= 68616. \text{ mm}^4 \\ y_g &= 24.54 \text{ mm} \\ T_y &= 3740. \text{ N} \\ M_x &= -1982200. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.46 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.3 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 16.46 \text{ mm} \\ \sigma_c &= -Mv/J_u = 115.2 \text{ N/mm}^2 \\ \tau_c &= 6.897 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 115.9 \text{ N/mm}^2 \\ S &= 6265. \text{ mm}^3 \end{aligned}$$



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⊕ ⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

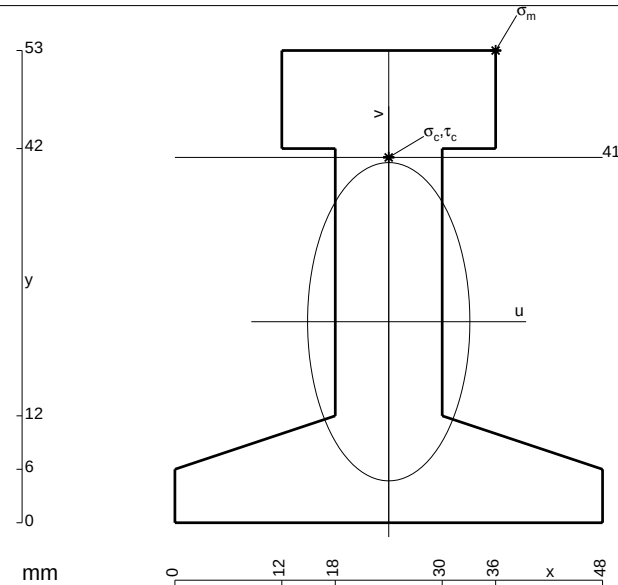
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

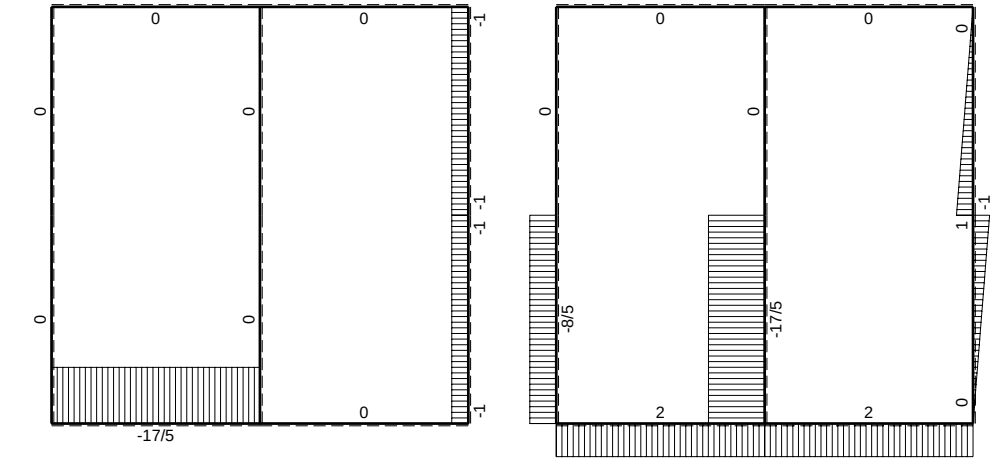
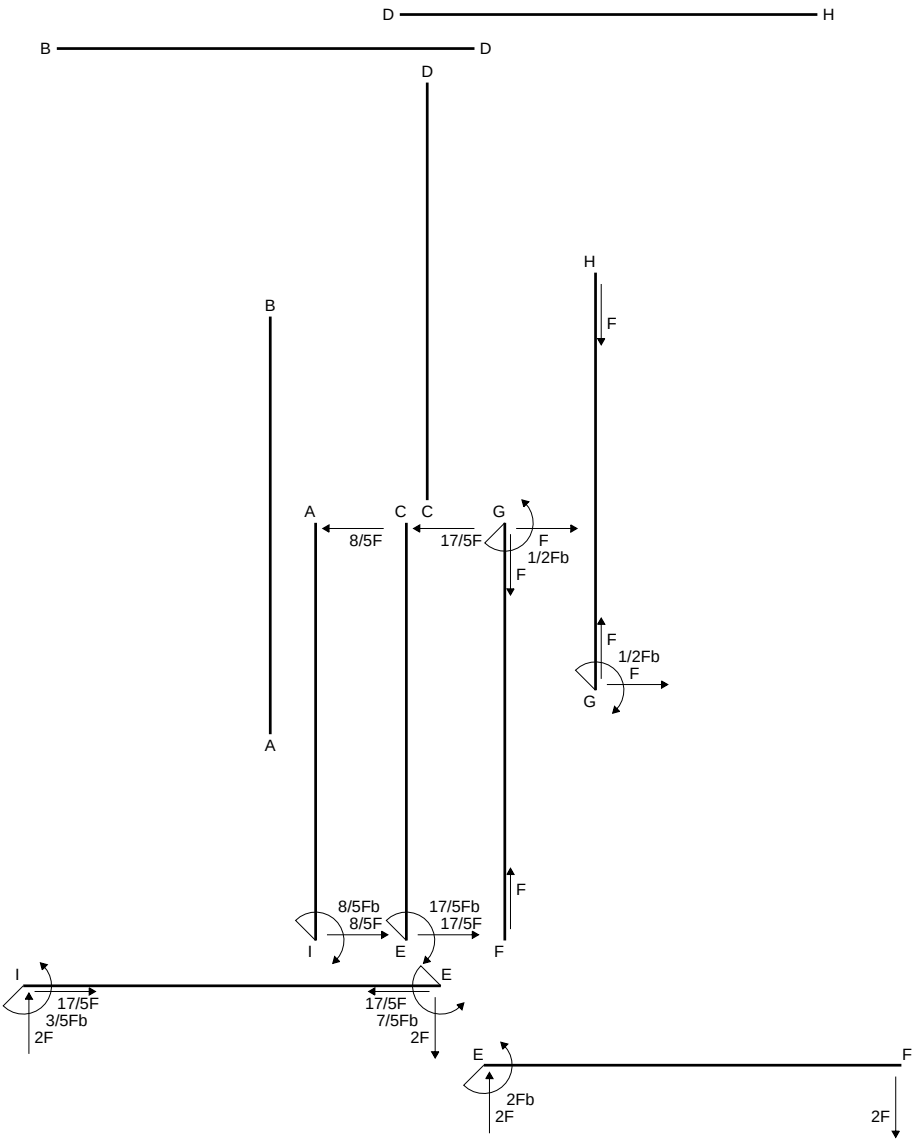
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

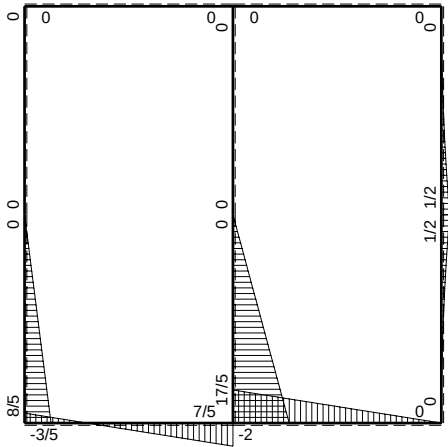


$$\begin{aligned} A &= 1092. \text{ mm}^2 \\ J_u &= 348585. \text{ mm}^4 \\ J_v &= 90648. \text{ mm}^4 \\ y_g &= 22.56 \text{ mm} \\ T_y &= 4140. \text{ N} \\ M_x &= -2401200. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.44 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 18.44 \text{ mm} \\ \sigma_c &= -Mv/J_u = 127. \text{ N/mm}^2 \\ \tau_c &= 6.741 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 127.6 \text{ N/mm}^2 \\ S &= 6811. \text{ mm}^3 \end{aligned}$$



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↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-Fx$	0	$Fb-2Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fx$	0	Fx^2/b	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

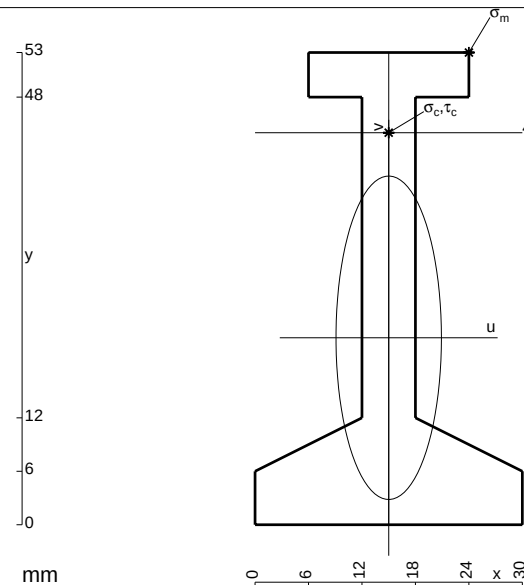
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 2x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

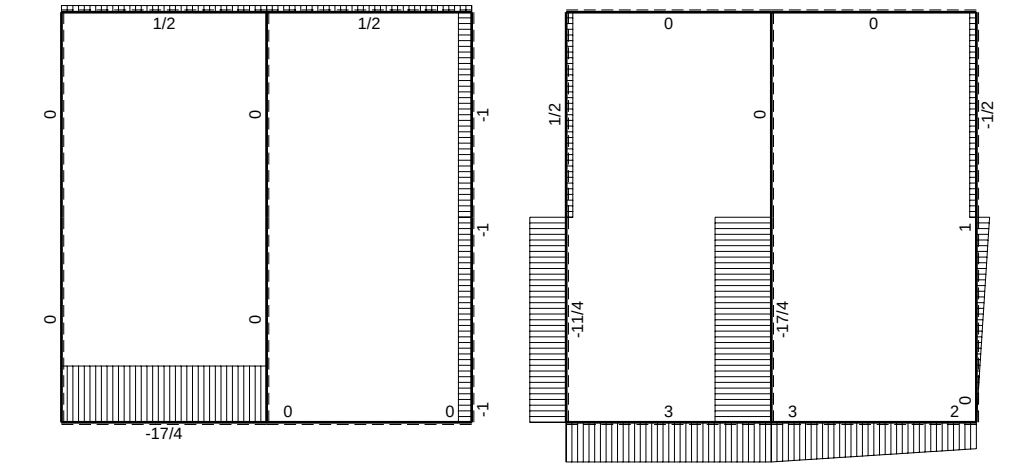
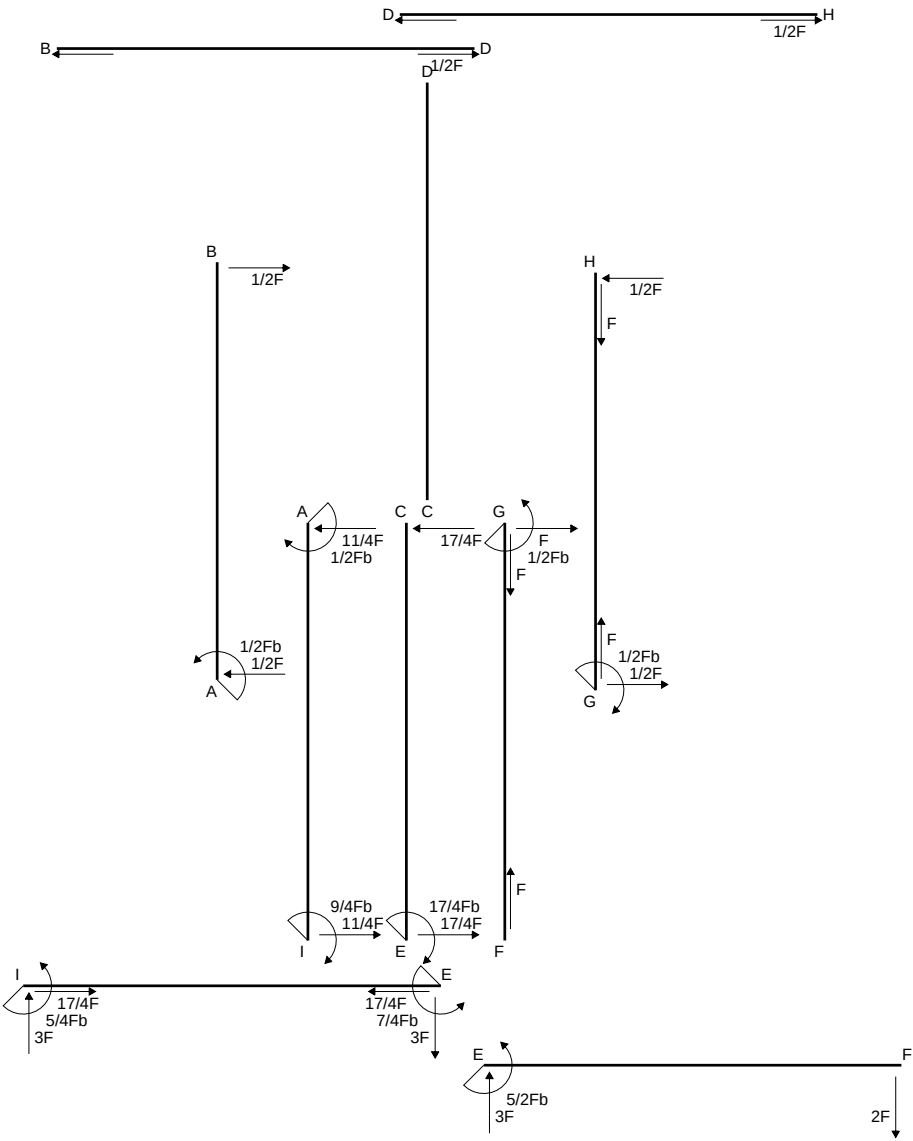
$$= (b - b + 1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/3 b) Fb \frac{1}{EJ} = 1/3 Fb^2/EJ$$

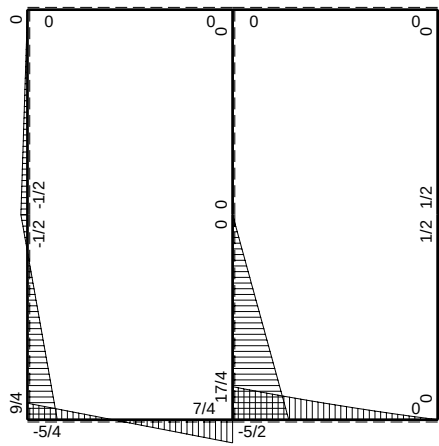


$$\begin{aligned} A &= 594. \text{ mm}^2 \\ J_u &= 195798. \text{ mm}^4 \\ J_v &= 20790. \text{ mm}^4 \\ y_g &= 20.98 \text{ mm} \\ T_y &= 2120. \text{ N} \\ M_x &= -1335600. \text{ Nmm} \\ x_m &= 24. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 32.02 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.4 \text{ N/mm}^2 \\ x_c &= 15. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 23.02 \text{ mm} \\ \sigma_c &= -Mv/J_u = 157. \text{ N/mm}^2 \\ \tau_c &= 5.877 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 157.3 \text{ N/mm}^2 \\ S &= 3257. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

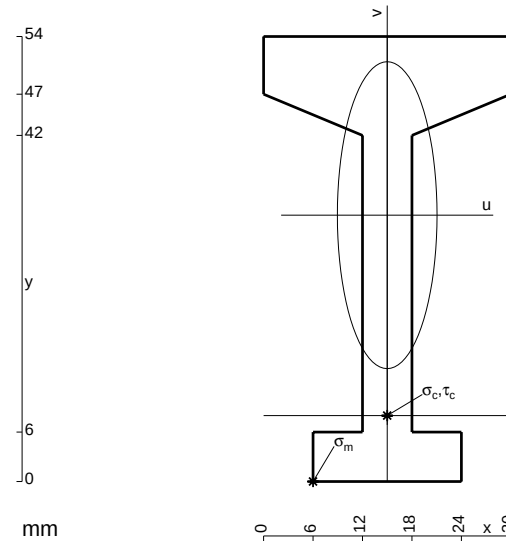
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 624. \text{ mm}^2$$

$$J_u = 216470. \text{ mm}^4$$

$$J_v = 22824. \text{ mm}^4$$

$$y_g = 32.32 \text{ mm}$$

$$T_y = 2640. \text{ N}$$

$$M_x = -1540000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -32.32 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.9 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 8. \text{ mm}$$

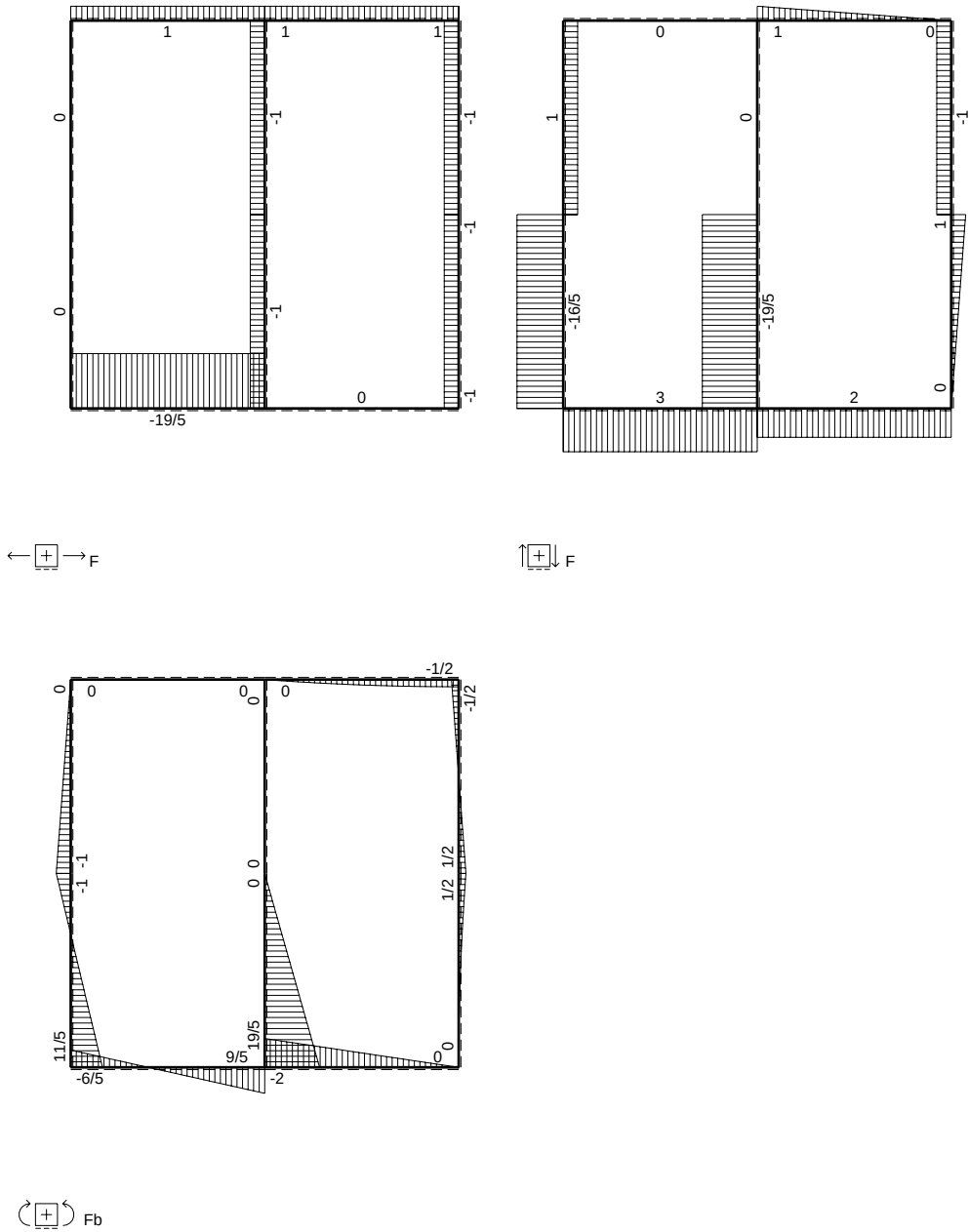
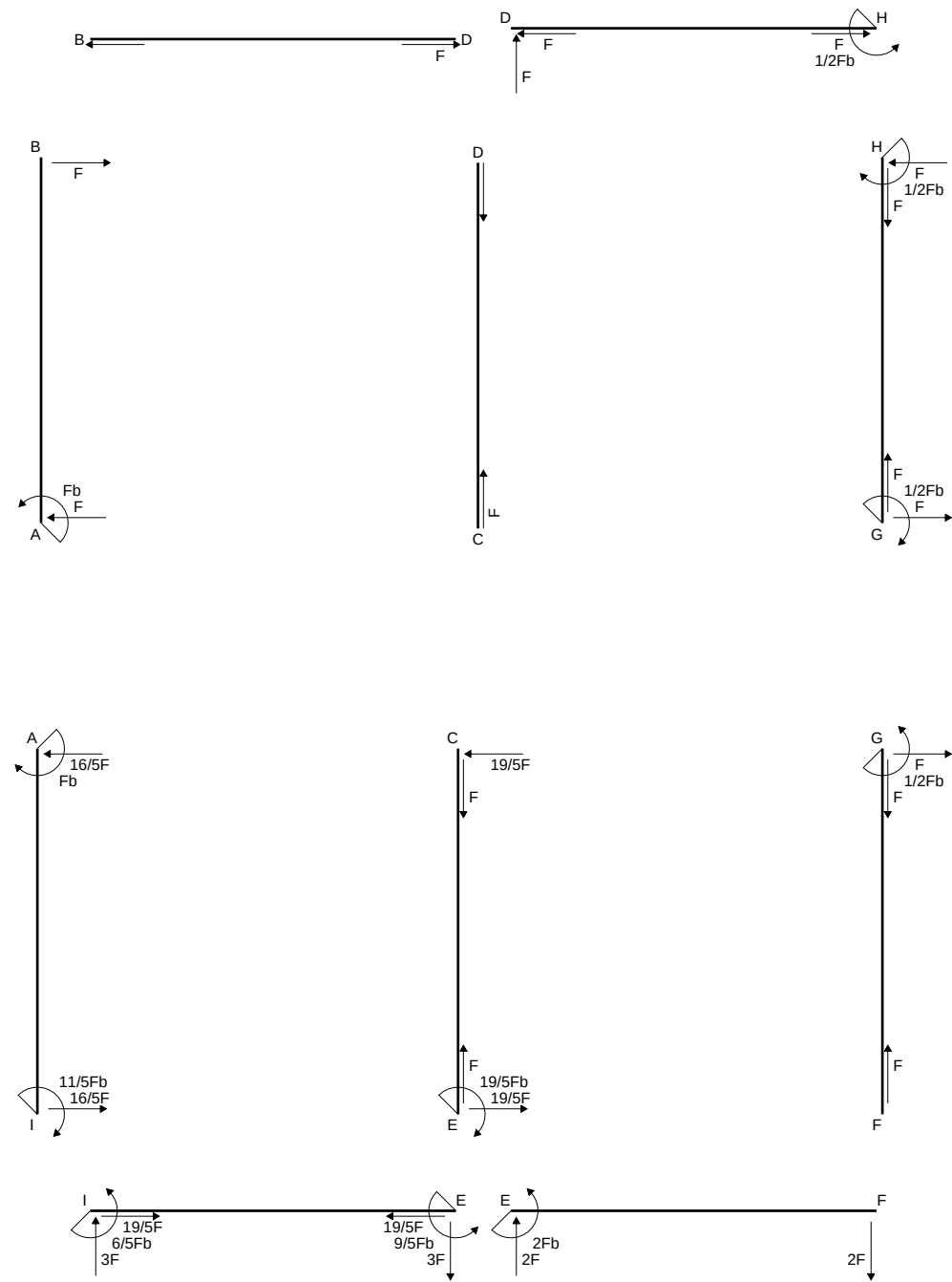
$$v_c = -24.32 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -173. \text{ N/mm}^2$$

$$\tau_c = 7.054 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 173.5 \text{ N/mm}^2$$

$$S = 3470. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-2Fx$	0	$Fb-3Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-2Fx$	0	$-Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

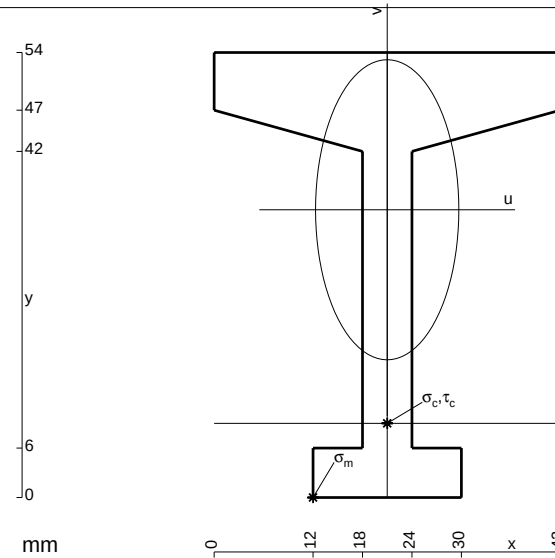
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (1 - 3x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/2 x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/2 b + 2/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (-x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 2/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 738. \text{ mm}^2$$

$$J_u = 244714. \text{ mm}^4$$

$$J_v = 55782. \text{ mm}^4$$

$$y_g = 34.92 \text{ mm}$$

$$T_y = 2240. \text{ N}$$

$$M_x = -1680000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.92 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.7 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

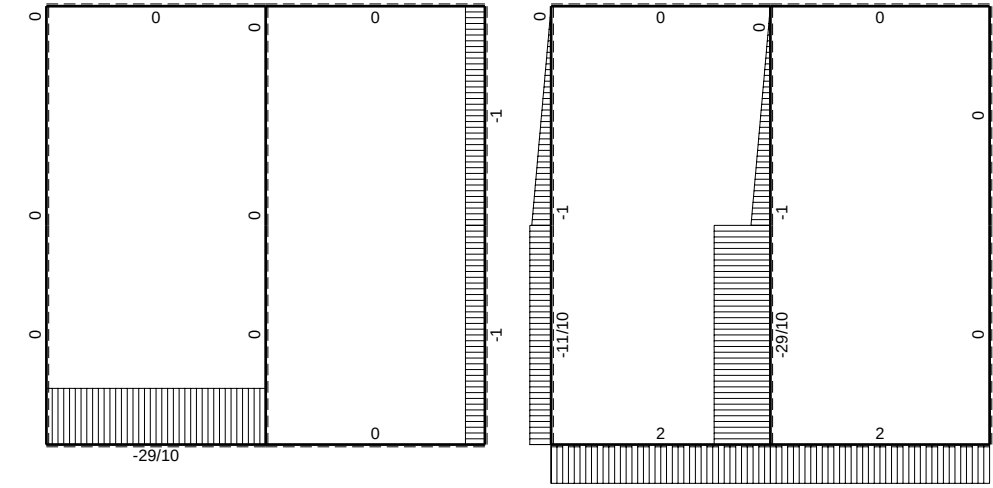
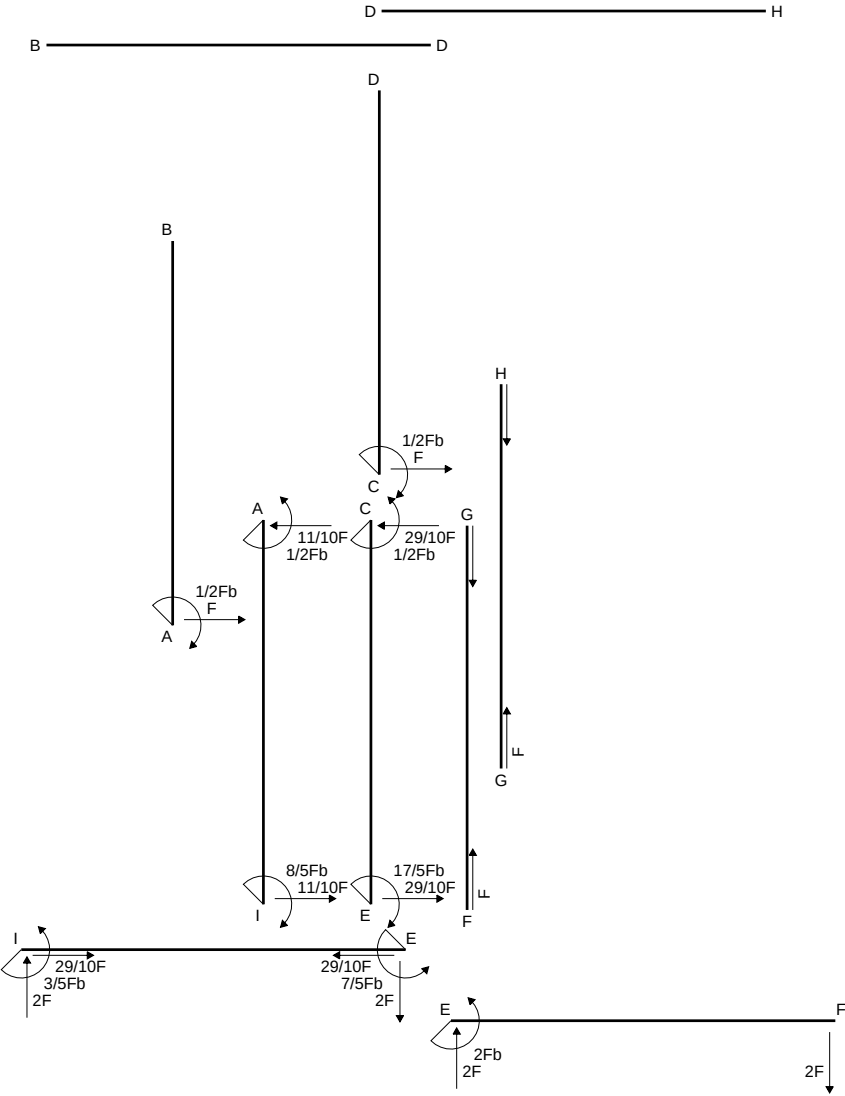
$$v_c = -25.92 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -177.9 \text{ N/mm}^2$$

$$\tau_c = 6.012 \text{ N/mm}^2$$

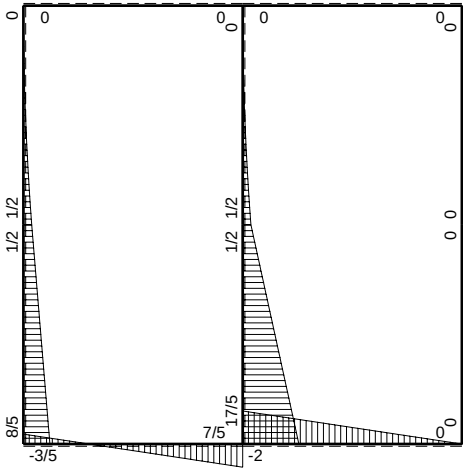
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 178.2 \text{ N/mm}^2$$

$$S = 3941. \text{ mm}^3$$

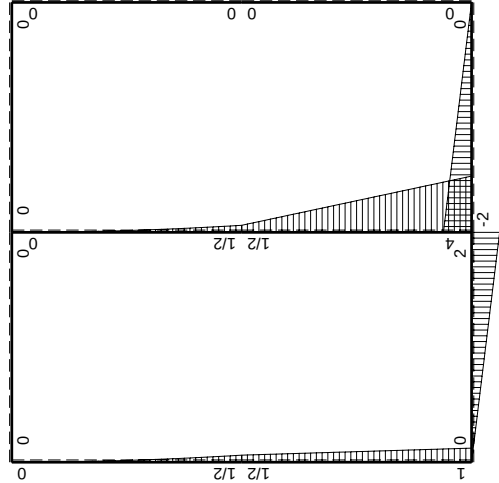
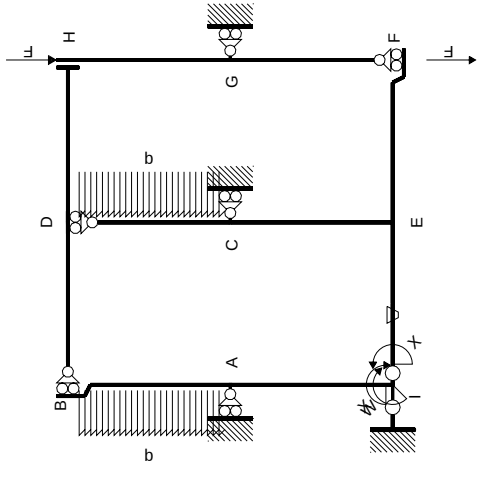


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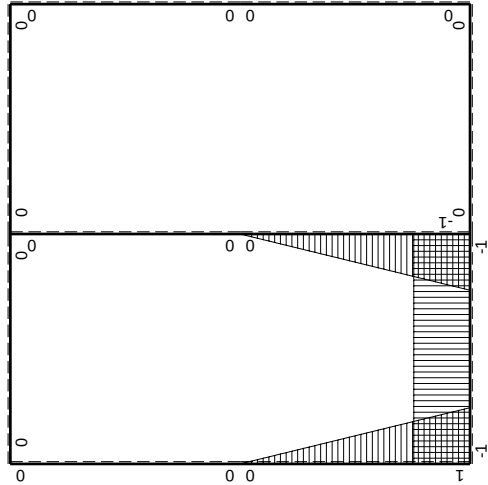


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_1 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2 qx^2$	0	0	0	0		
CD b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2 qx^2$	0	0	0	0		
EF b	0	$-2Fb + 2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb + 2Fx$	Fb/EJ	$-2Fb + 2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb - 7/2 Fx$	0	$-4Fb + 15/2 Fx - 7/2 Fx^2/b$	0	$1 - 2x/b + x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3 Xb/EJ$
CE b	x/b	$-1/2 Fb - 7/2 Fx$	0	$-1/2 Fx - 7/2 Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb - 1/2 Fx$	0	$Fb - 3/2 Fx + 1/2 Fx^2/b$	0	$1 - 2x/b + x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3 Xb/EJ$
AI b	$-x/b$	$-1/2 Fb - 1/2 Fx$	0	$1/2 Fx + 1/2 Fx^2/b$	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3 Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5 Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 15/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

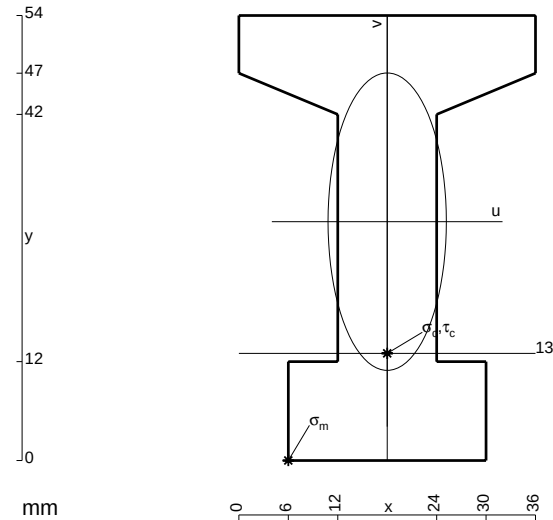
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



$$A = 1020. \text{ mm}^2$$

$$J_u = 332394. \text{ mm}^4$$

$$J_v = 52560. \text{ mm}^4$$

$$y_g = 28.98 \text{ mm}$$

$$T_y = 2820. \text{ N}$$

$$M_x = -2284200. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.98 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.2 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

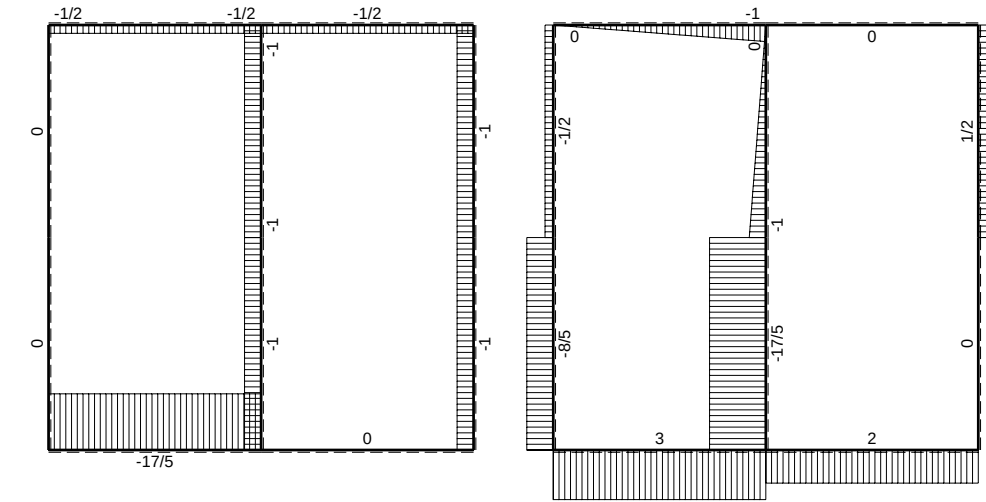
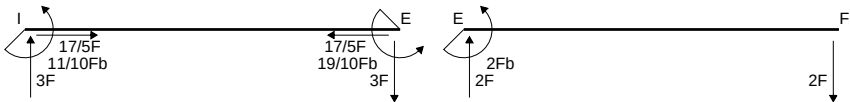
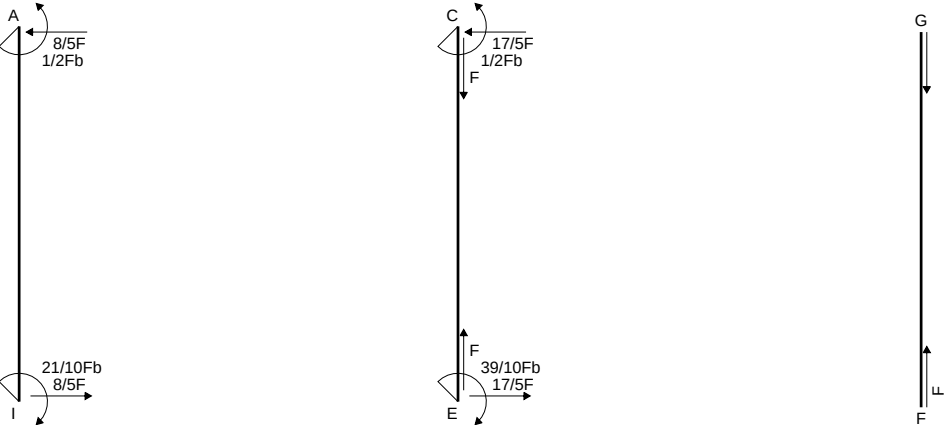
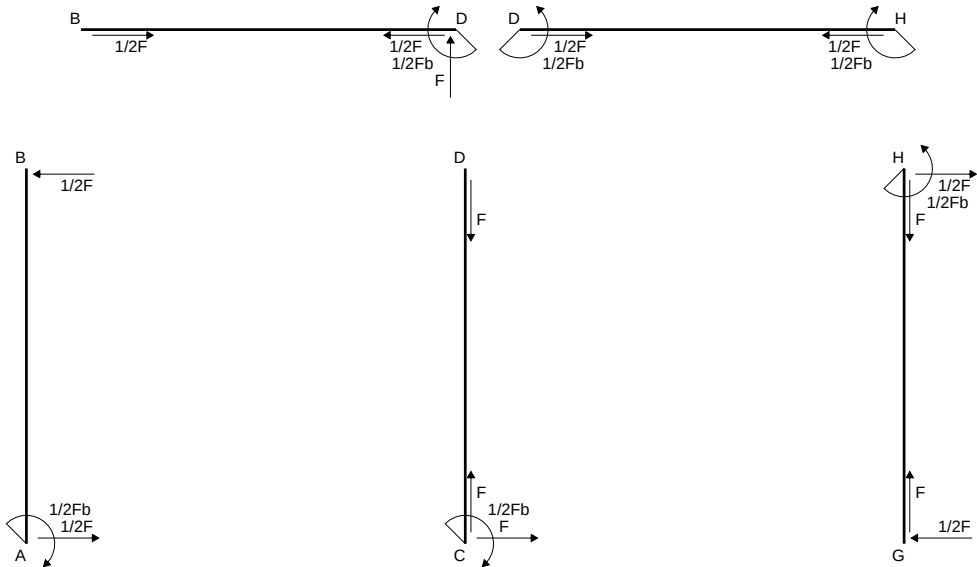
$$v_c = -15.98 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -109.8 \text{ N/mm}^2$$

$$\tau_c = 4.82 \text{ N/mm}^2$$

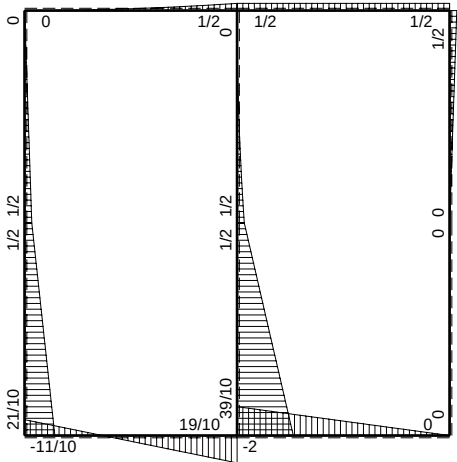
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 110.2 \text{ N/mm}^2$$

$$S = 6817. \text{ mm}^3$$

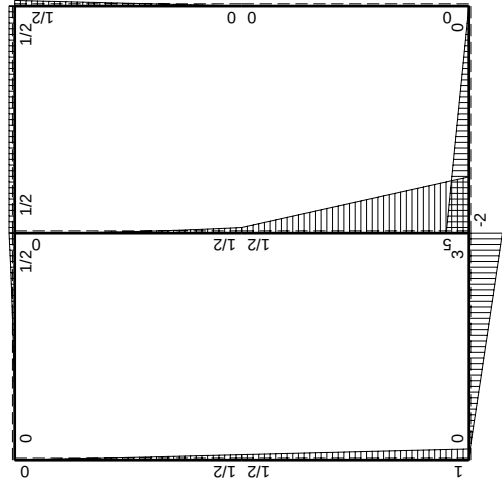
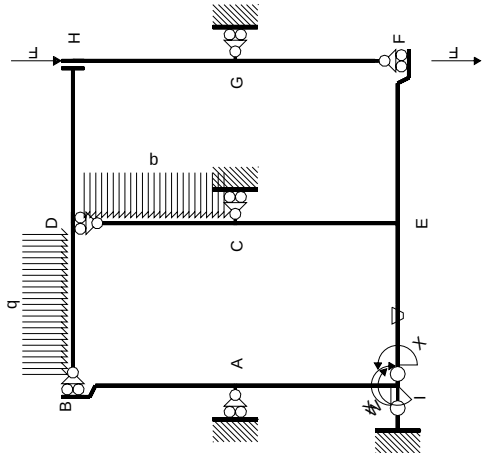


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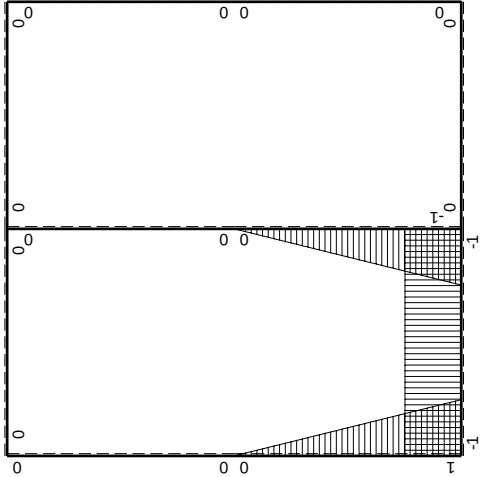


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 19/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

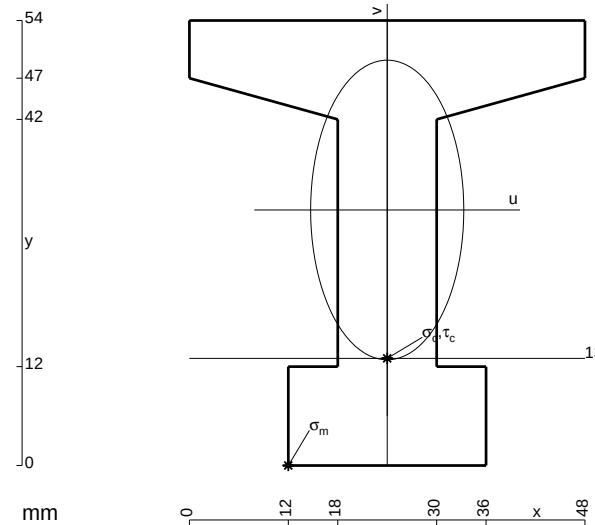
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



$$A = 1134. \text{ mm}^2$$

$$J_u = 375027. \text{ mm}^4$$

$$J_v = 97956. \text{ mm}^4$$

$$y_g = 31.01 \text{ mm}$$

$$T_y = 2940. \text{ N}$$

$$M_x = -2528400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -31.01 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.1 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

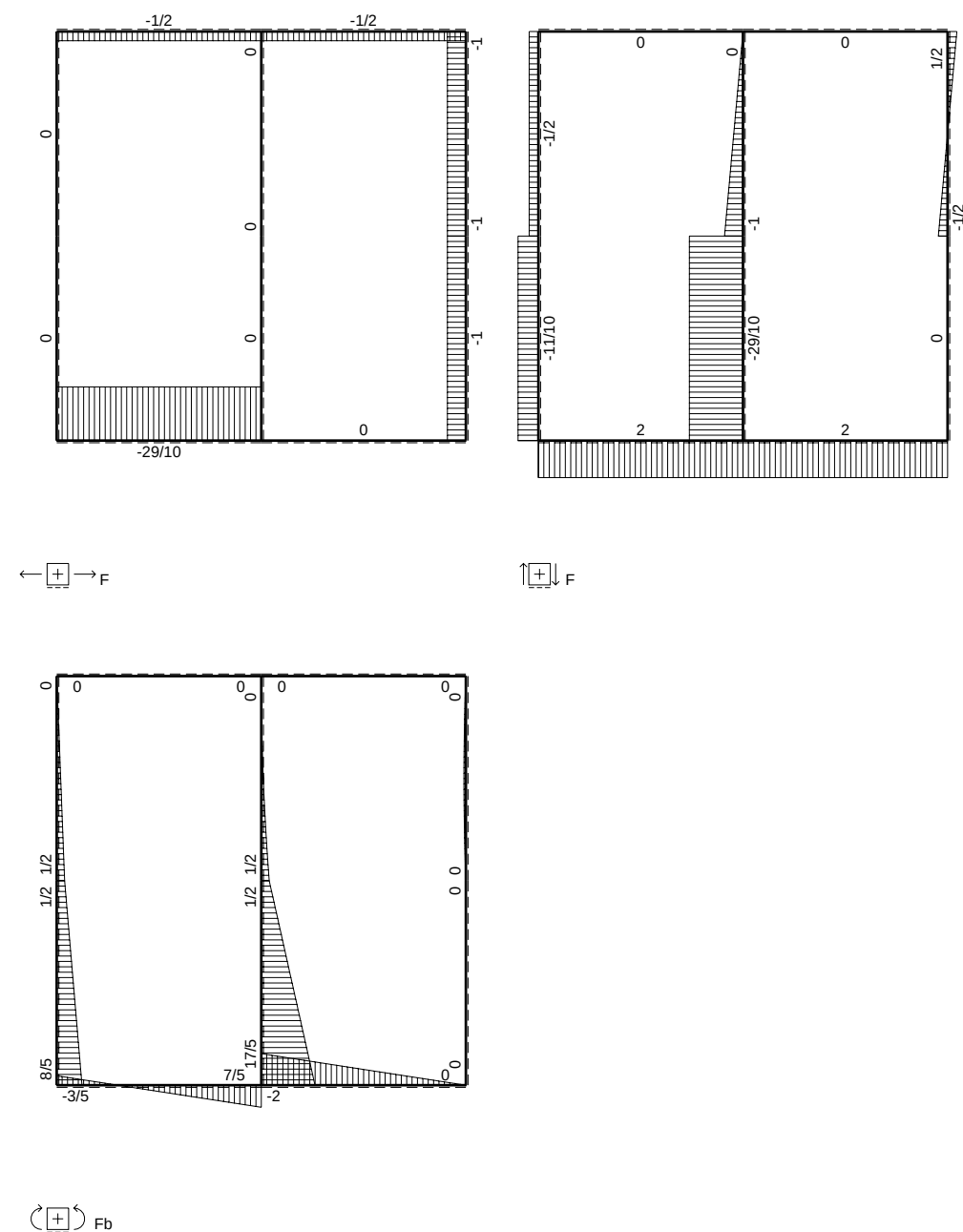
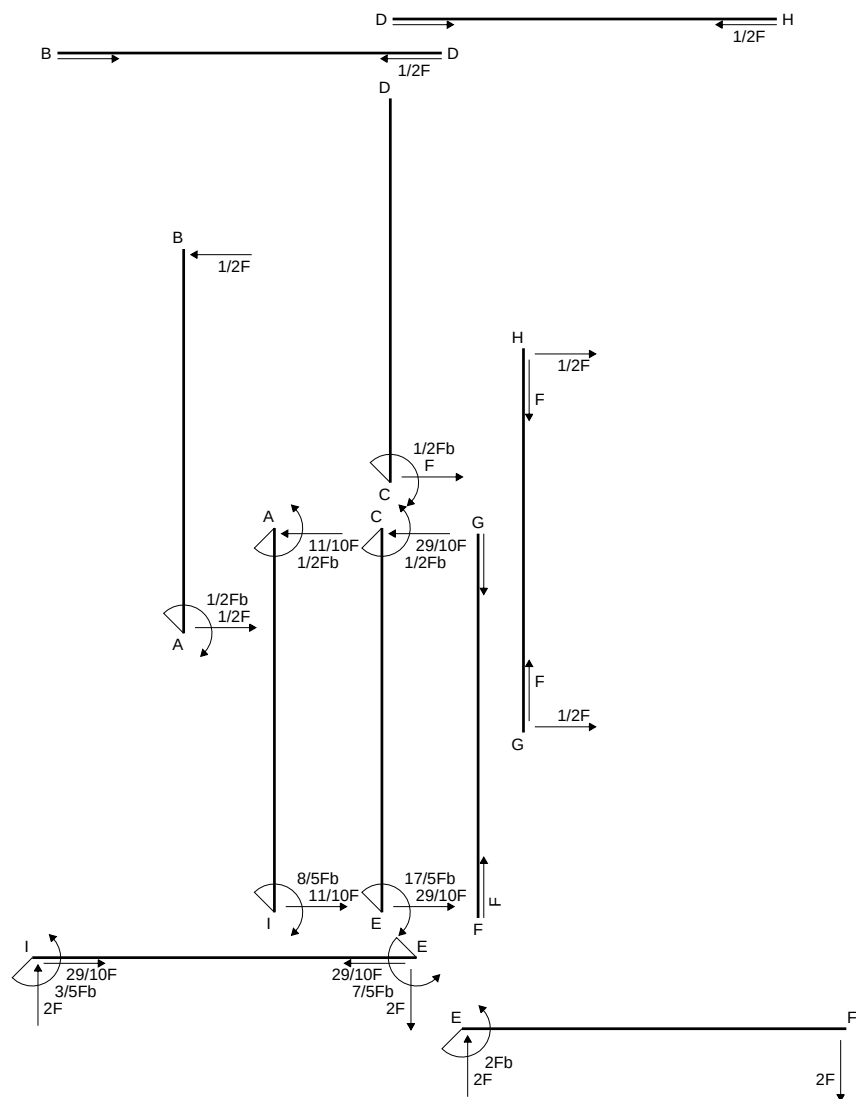
$$v_c = -18.01 \text{ mm}$$

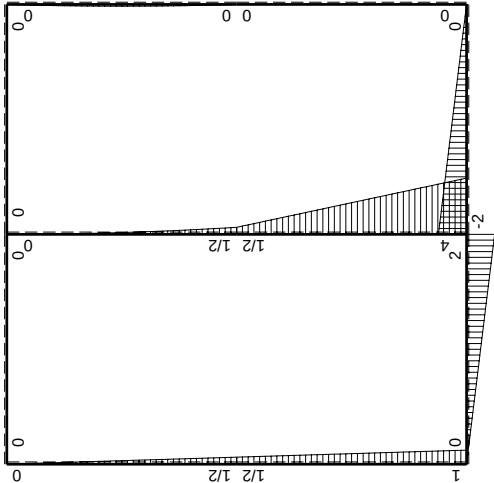
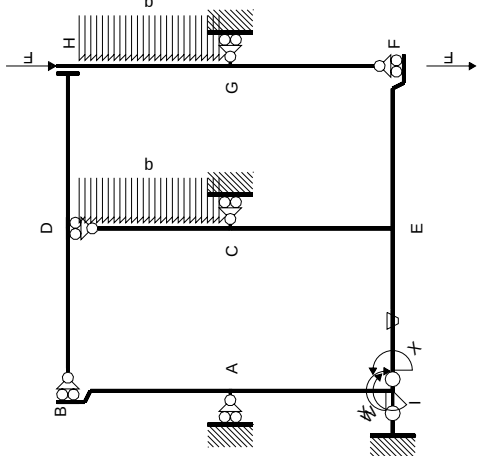
$$\sigma_c = -Mv/J_u = -121.4 \text{ N/mm}^2$$

$$\tau_c = 4.851 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 121.7 \text{ N/mm}^2$$

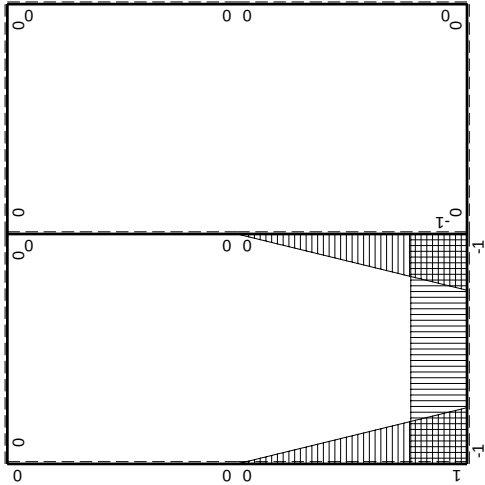
$$S = 7425. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-1/2Fx$	0	$Fb-3/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(5/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb-1/2Fx$	0	$1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 15/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

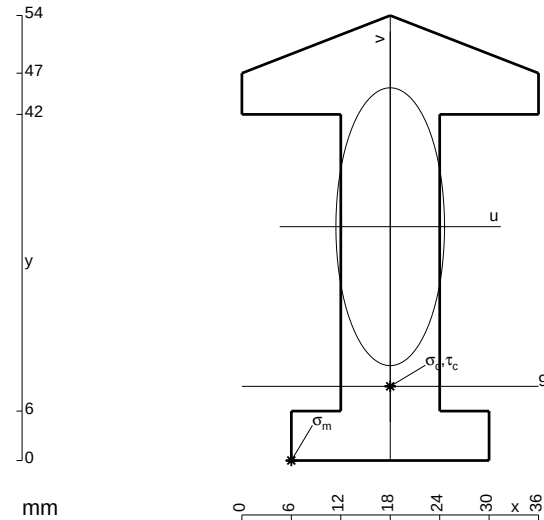
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 3/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 3/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 3/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b + 1/6 b) Fb \frac{1}{EJ} = 5/12 Fb^2/EJ$$



$$A = 882. \text{ mm}^2$$

$$J_u = 250944. \text{ mm}^4$$

$$J_v = 38340. \text{ mm}^4$$

$$y_g = 28.37 \text{ mm}$$

$$T_y = 2120. \text{ N}$$

$$M_x = -1929200. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.37 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218.1 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

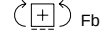
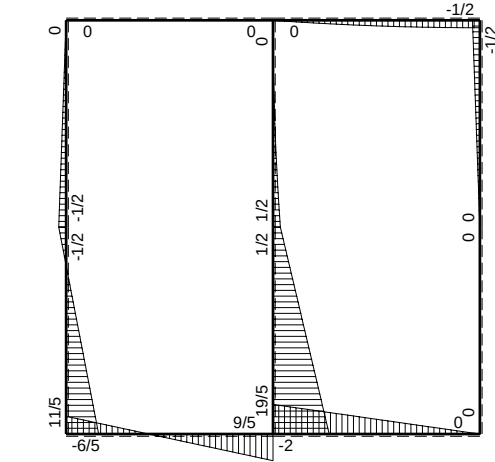
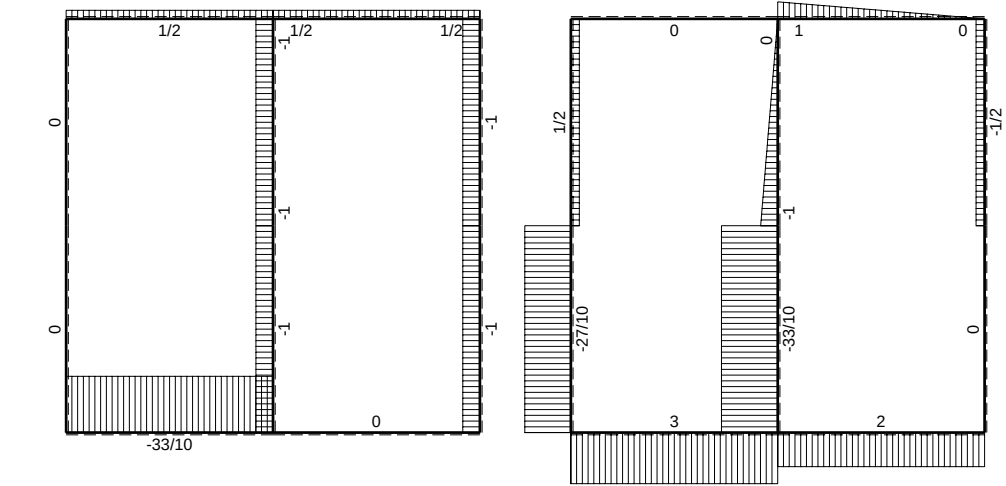
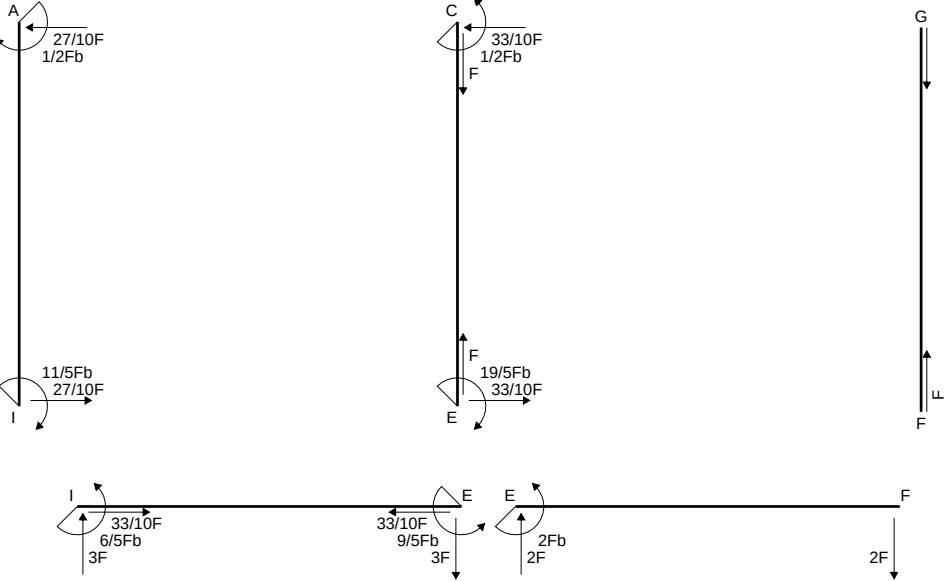
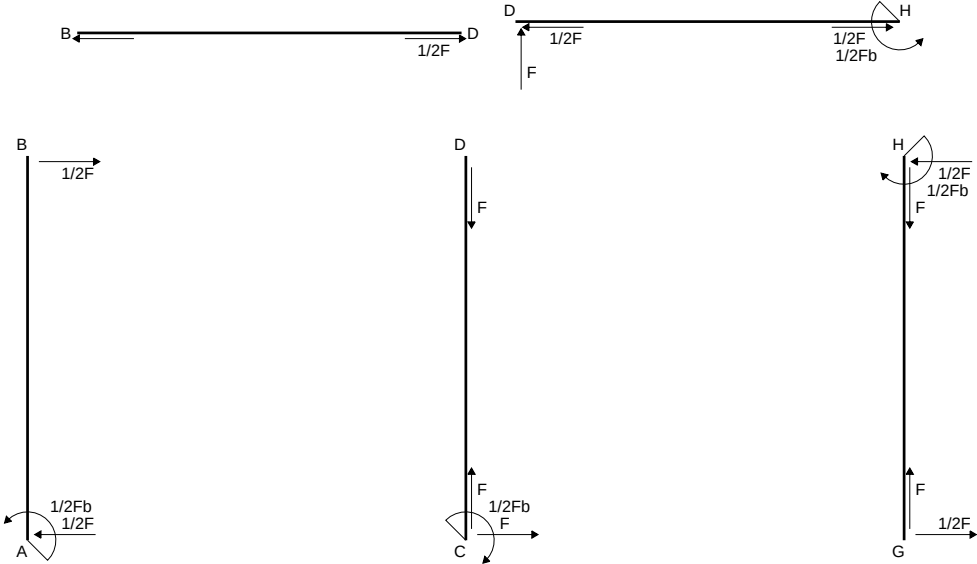
$$v_c = -19.37 \text{ mm}$$

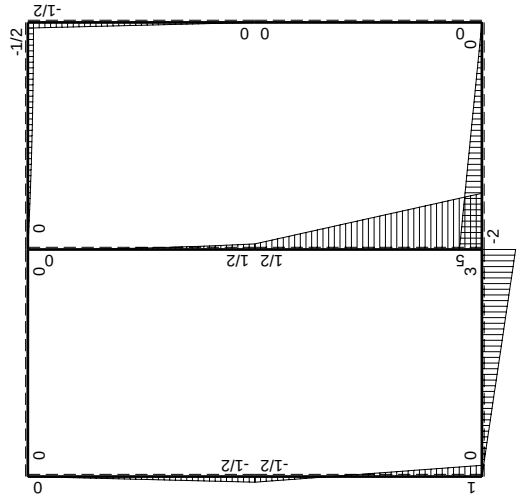
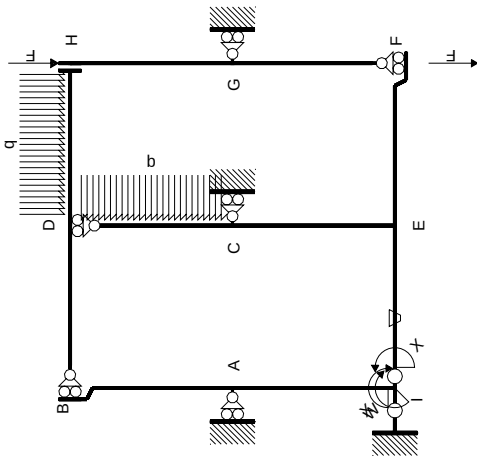
$$\sigma_c = -Mv/J_u = -148.9 \text{ N/mm}^2$$

$$\tau_c = 3.101 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 149. \text{ N/mm}^2$$

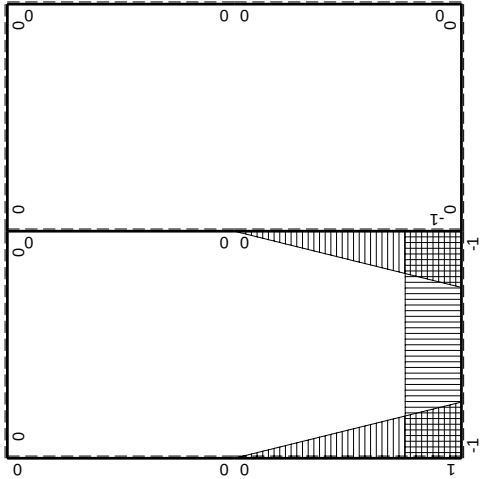
$$S^* = 4405. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 19/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

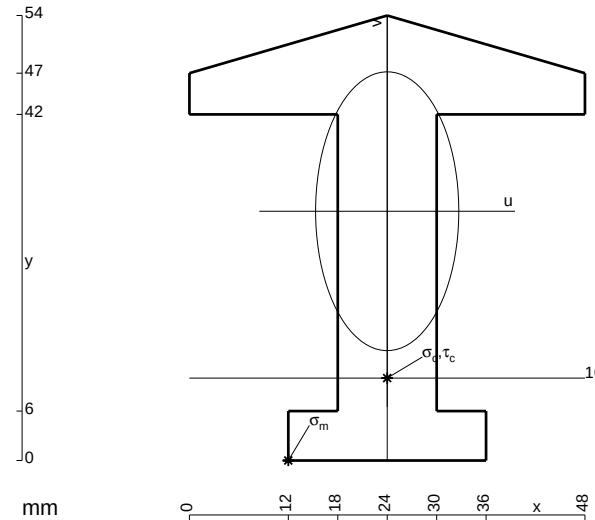
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 984. \text{ mm}^2$$

$$J_u = 281765. \text{ mm}^4$$

$$J_v = 74304. \text{ mm}^4$$

$$y_g = 30.25 \text{ mm}$$

$$T_y = 2200. \text{ N}$$

$$M_x = -2134000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.25 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.1 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

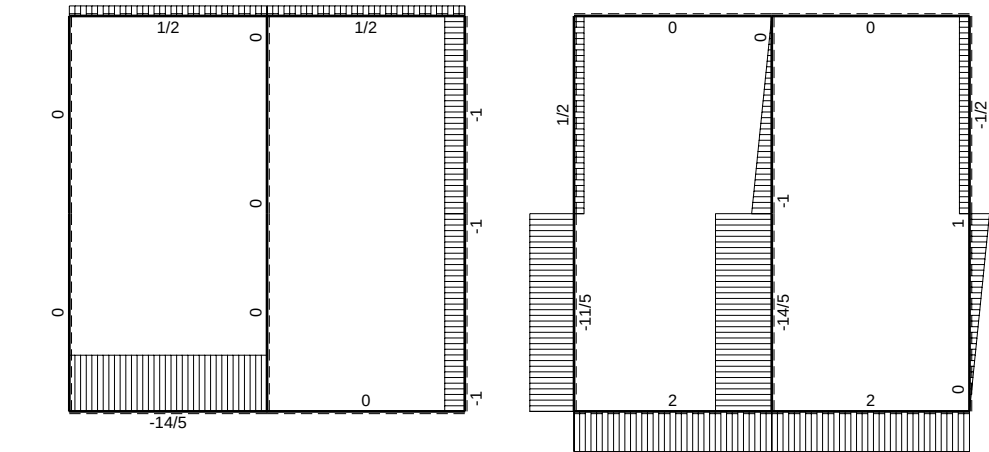
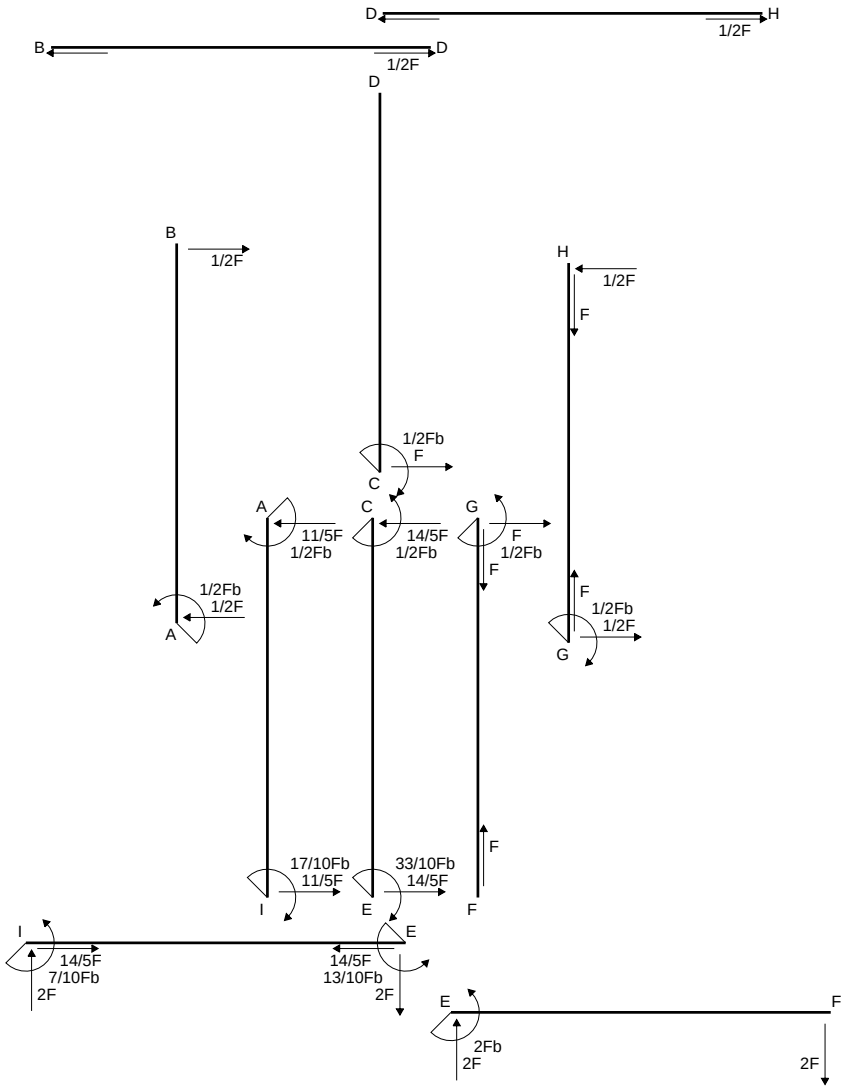
$$v_c = -20.25 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -153.4 \text{ N/mm}^2$$

$$\tau_c = 3.248 \text{ N/mm}^2$$

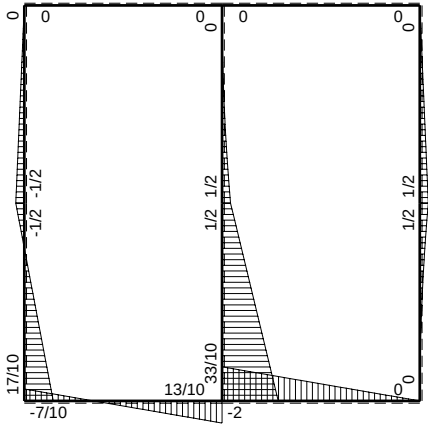
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 153.5 \text{ N/mm}^2$$

$$S = 4992. \text{ mm}^3$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ F_b

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$Fb-3/2Fx$	0	$Fb-5/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-3/2Fx$	0	$-1/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x\theta} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x\theta} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 15/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

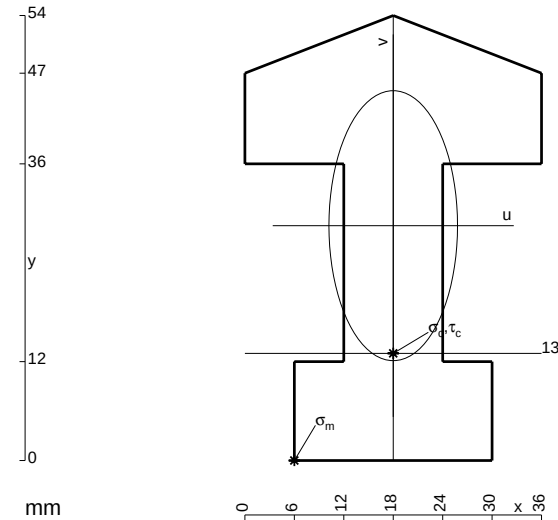
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (1 - 5/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[x - 5/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (b - 5/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (-1/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/2 b) Fb \frac{1}{EJ} = 1/4 Fb^2/EJ$$



$$A = 1098. \text{ mm}^2$$

$$J_u = 294859. \text{ mm}^4$$

$$J_v = 66852. \text{ mm}^4$$

$$y_g = 28.5 \text{ mm}$$

$$T_y = 2420. \text{ N}$$

$$M_x = -2468400. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.5 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -238.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

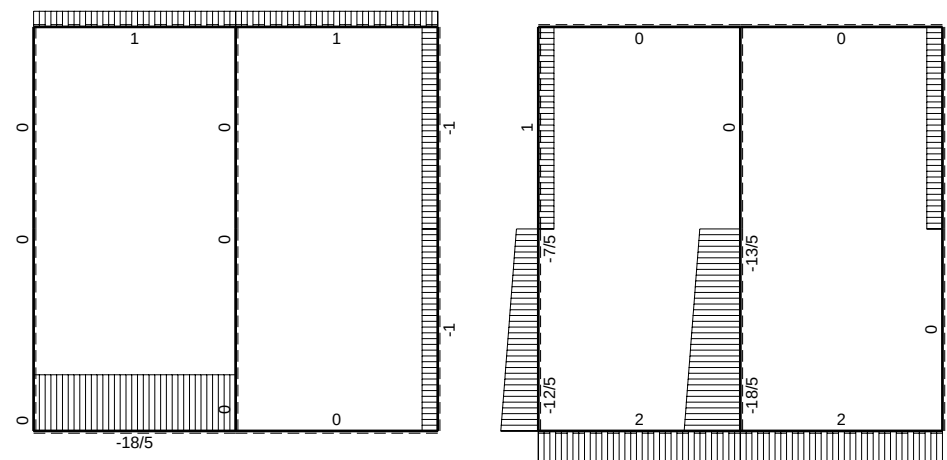
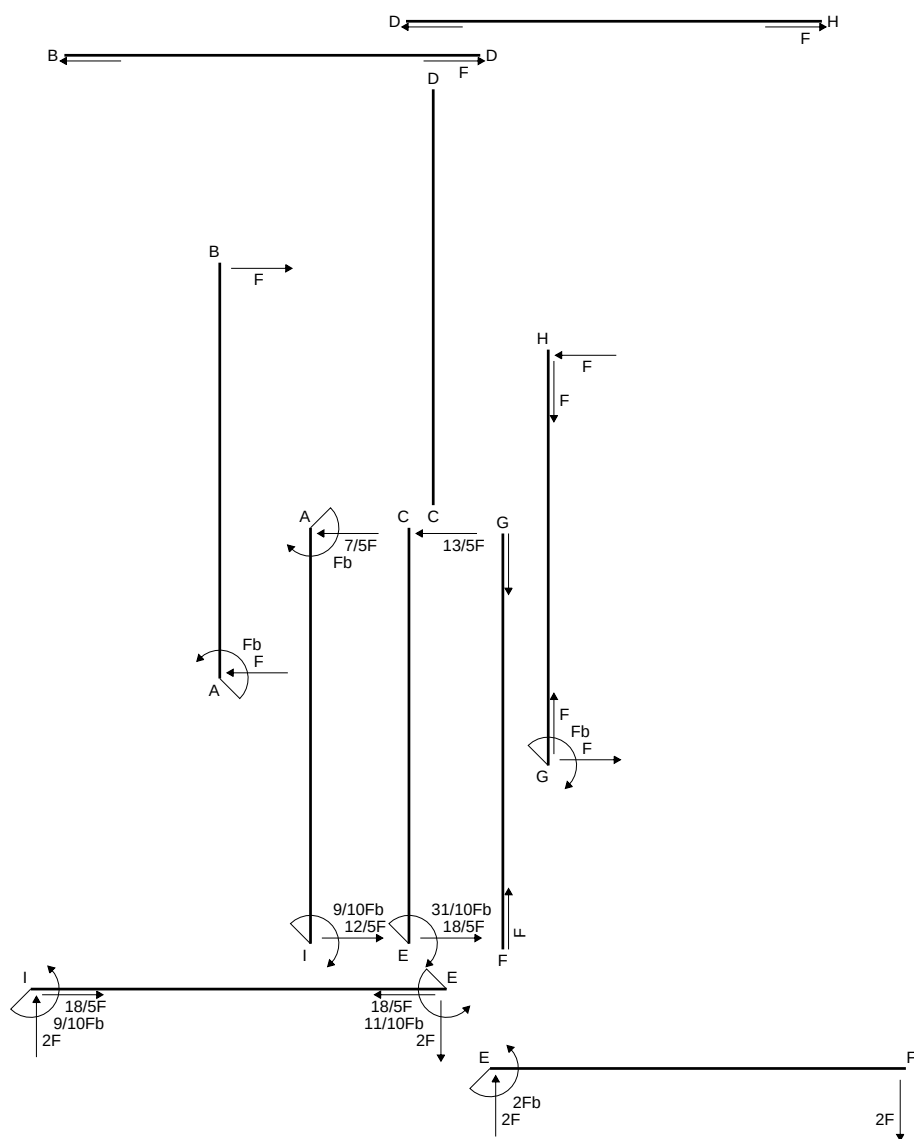
$$v_c = -15.5 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -129.7 \text{ N/mm}^2$$

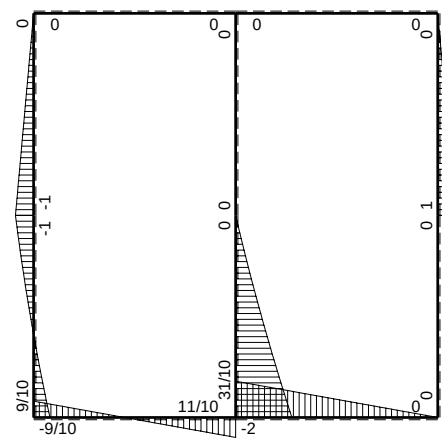
$$\tau_c = 4.563 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 130. \text{ N/mm}^2$$

$$S^* = 6671. \text{ mm}^3$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

$\uparrow \boxed{+} \downarrow F$



 F_b

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx+1/2qx^2$	0	$-3/2Fx+2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-5/24+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-1/2Fx-1/2qx^2$	0	$-Fx+1/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= \left[-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-7/6 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

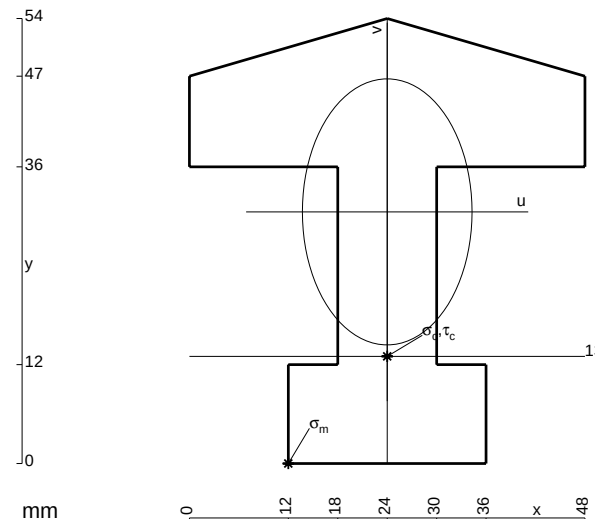
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 2x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 2/3 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

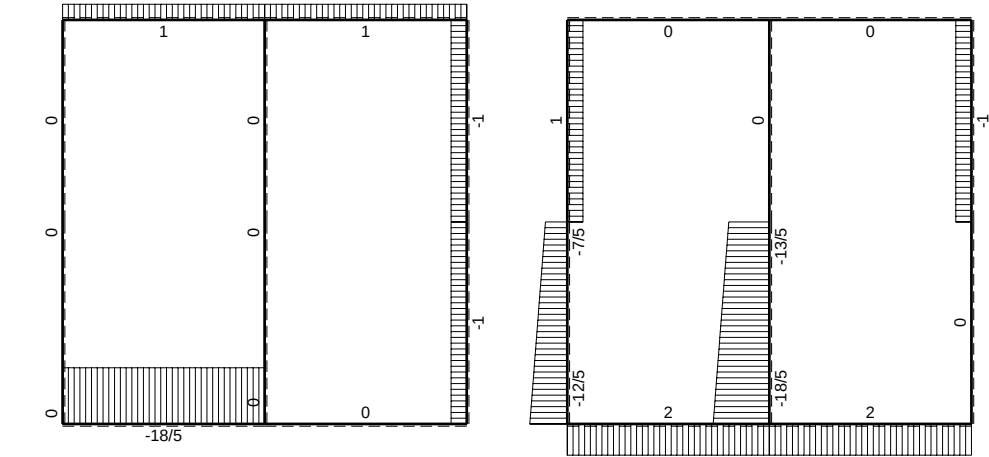
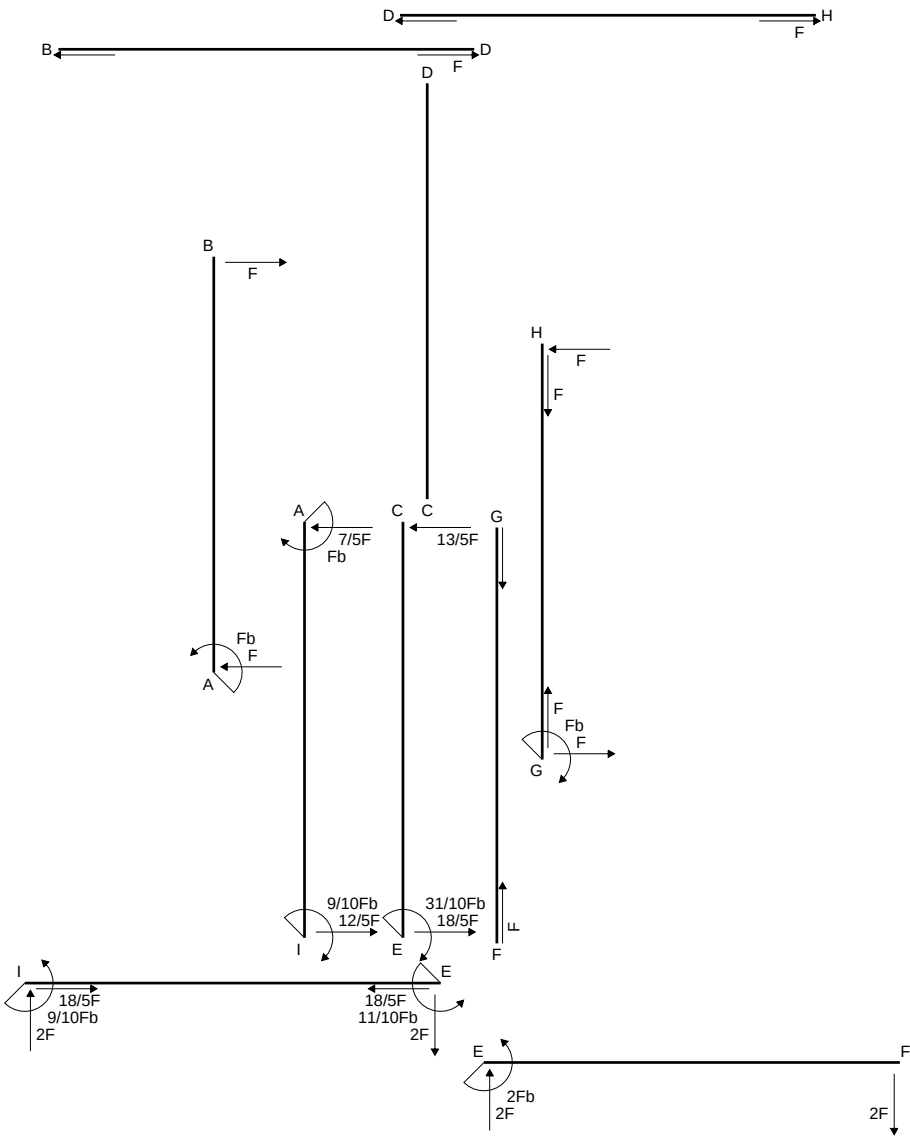
$$= (-3/4 b + 2/3 b - 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + 1/2 x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/6 x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/6 b + 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

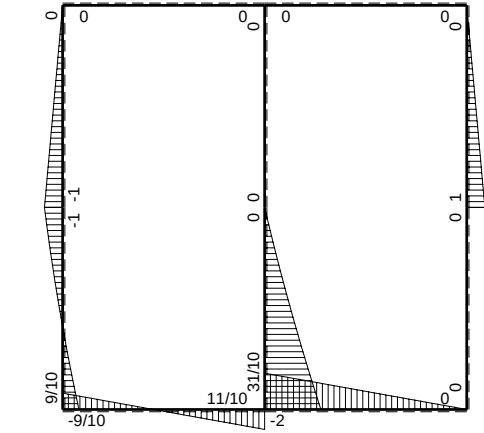


$$\begin{aligned} A &= 1272. \text{ mm}^2 \\ J_u &= 331576. \text{ mm}^4 \\ J_v &= 134784. \text{ mm}^4 \\ y_g &= 30.53 \text{ mm} \\ T_y &= 4020. \text{ N} \\ M_x &= -2170800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.53 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.53 \text{ mm} \\ \sigma_c &= -Mv/J_u = -114.8 \text{ N/mm}^2 \\ \tau_c &= 7.358 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 115.5 \text{ N/mm}^2 \\ S &= 7282. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ F_b

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx+1/2qx^2$	0	$-4Fb+17/2Fx-5Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-31/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-7/2Fx-1/2qx^2$	0	$-7/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx+1/2qx^2$	0	$-3/2Fx+2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-5/24+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-1/2Fx-1/2qx^2$	0	$-Fx+1/2Fx^2/b+1/2qx^3/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 5x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= \left[-4x + 17/4 x^2/b - 5/3 x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 5/3 b + 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-7/6 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

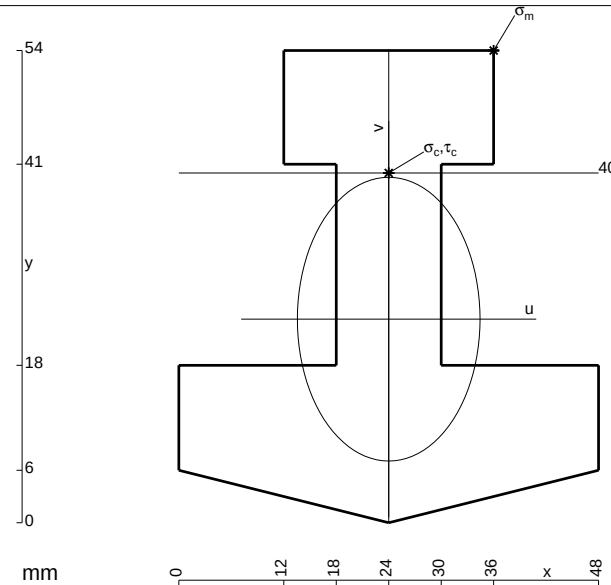
$$= (-7/6 b - 1/8 b) Fb \frac{1}{EJ} = -31/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 2x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 2/3 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

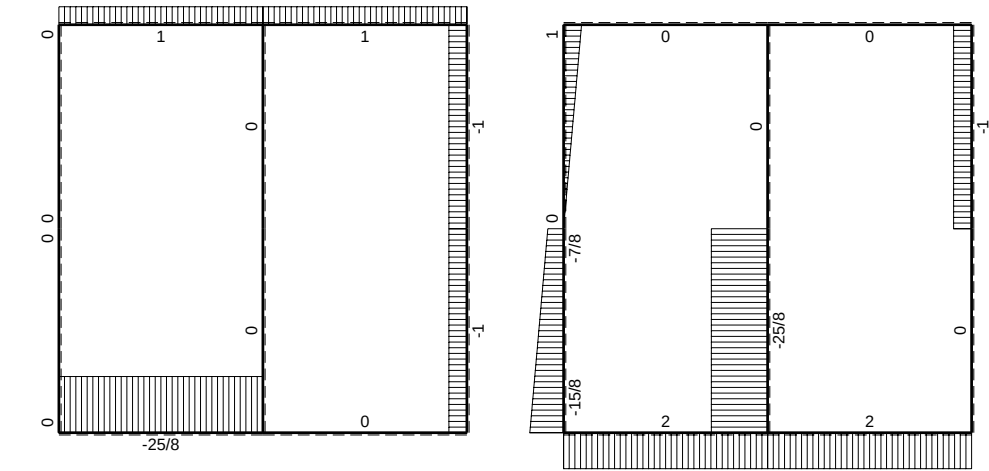
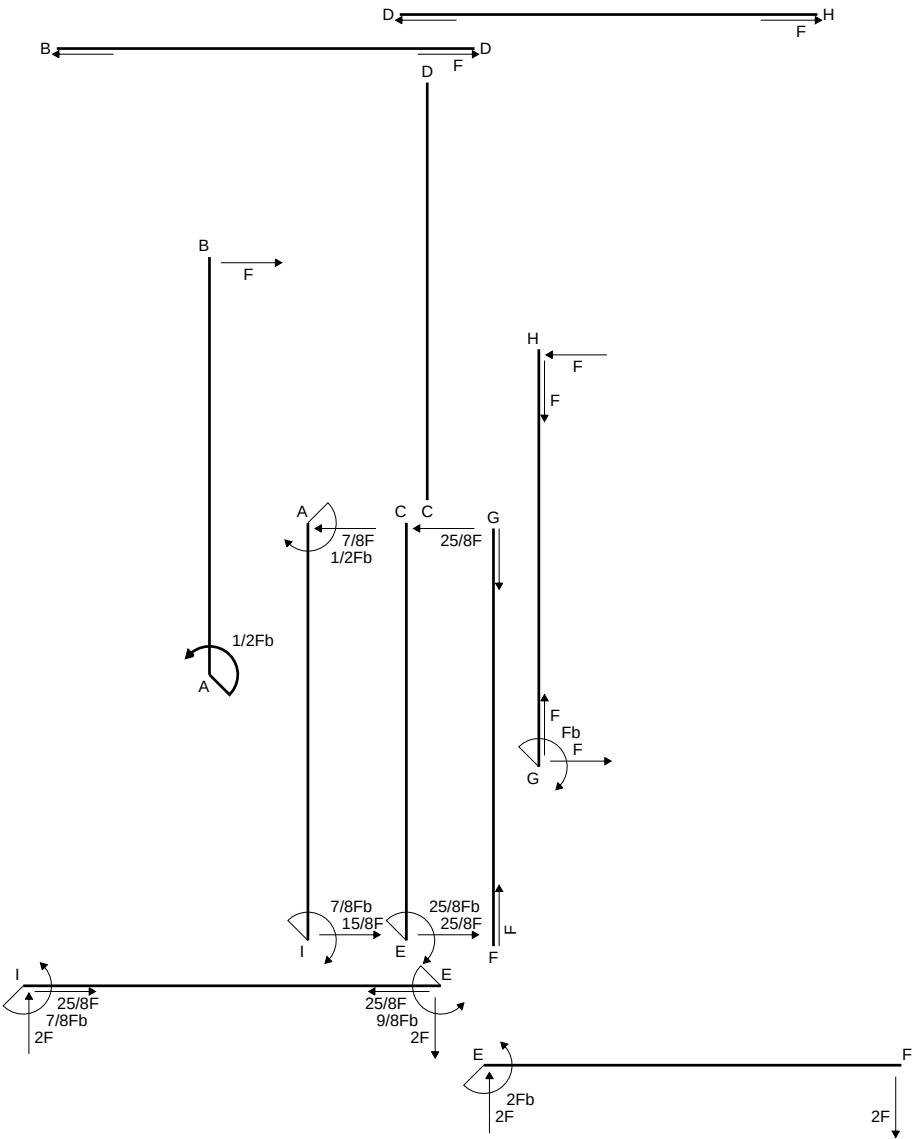
$$= (-3/4 b + 2/3 b - 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + 1/2 x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/6 x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/6 b + 1/8 b) Fb \frac{1}{EJ} = -5/24 Fb^2/EJ$$

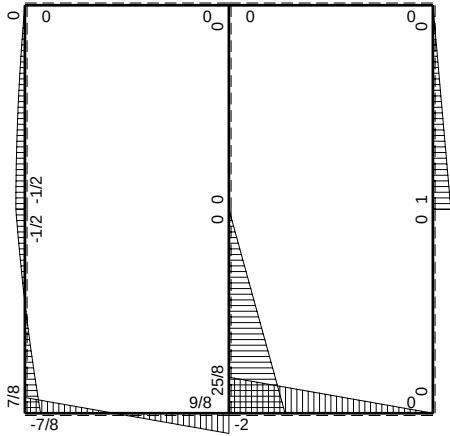


$$\begin{aligned} A &= 1308. \text{ mm}^2 \\ J_u &= 344278. \text{ mm}^4 \\ J_v &= 142704. \text{ mm}^4 \\ y_g &= 23.28 \text{ mm} \\ T_y &= 3980. \text{ N} \\ M_x &= -2348200. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.72 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 16.72 \text{ mm} \\ \sigma_c &= -Mv/J_u = 114. \text{ N/mm}^2 \\ \tau_c &= 7.479 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 114.8 \text{ N/mm}^2 \\ S &= 7763. \text{ mm}^3 \end{aligned}$$

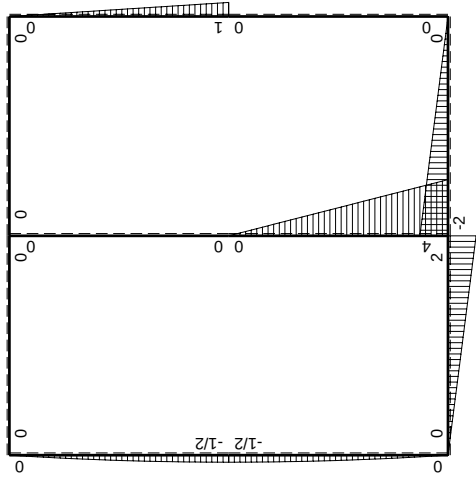
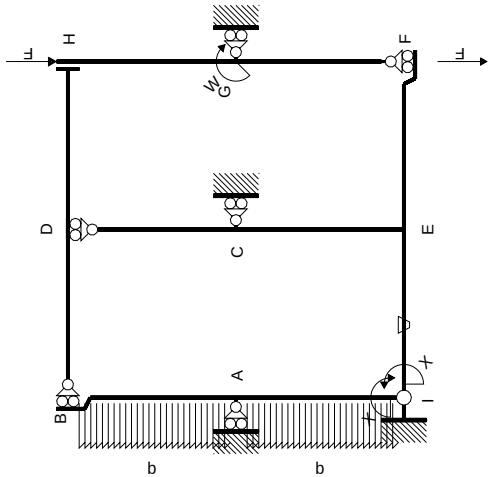


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

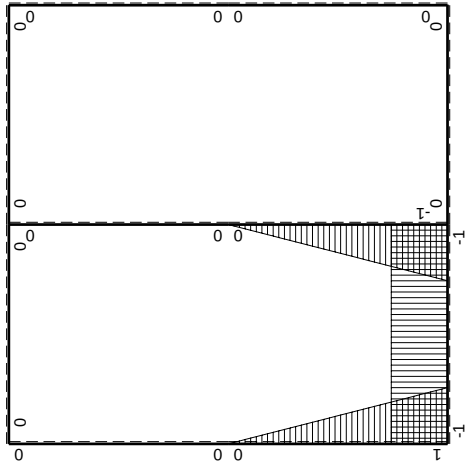


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati

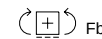
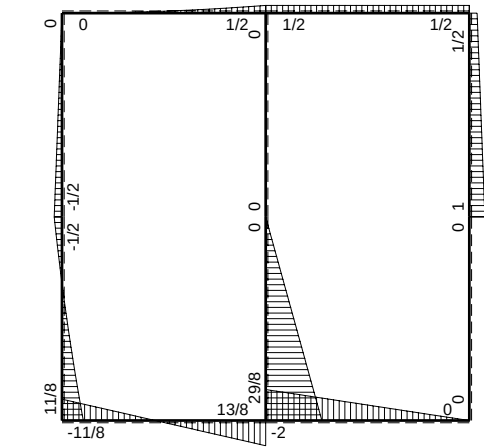
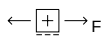
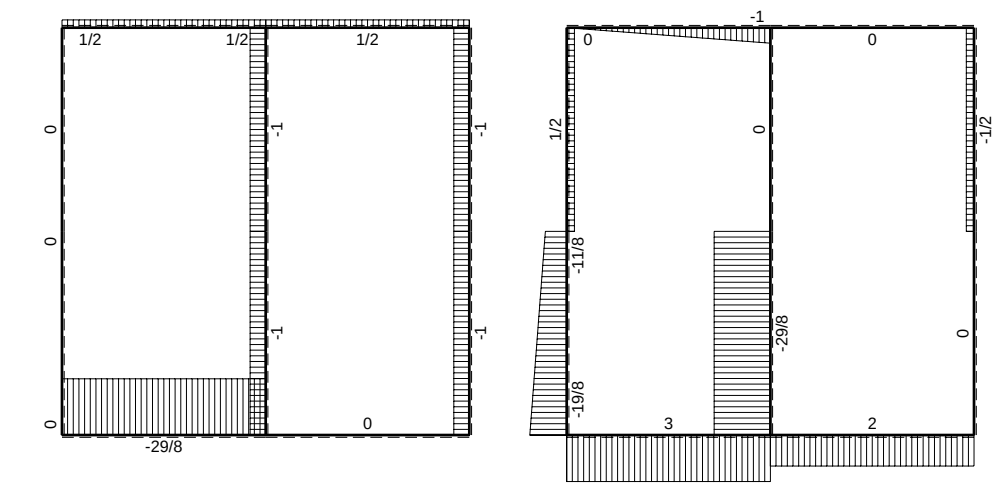
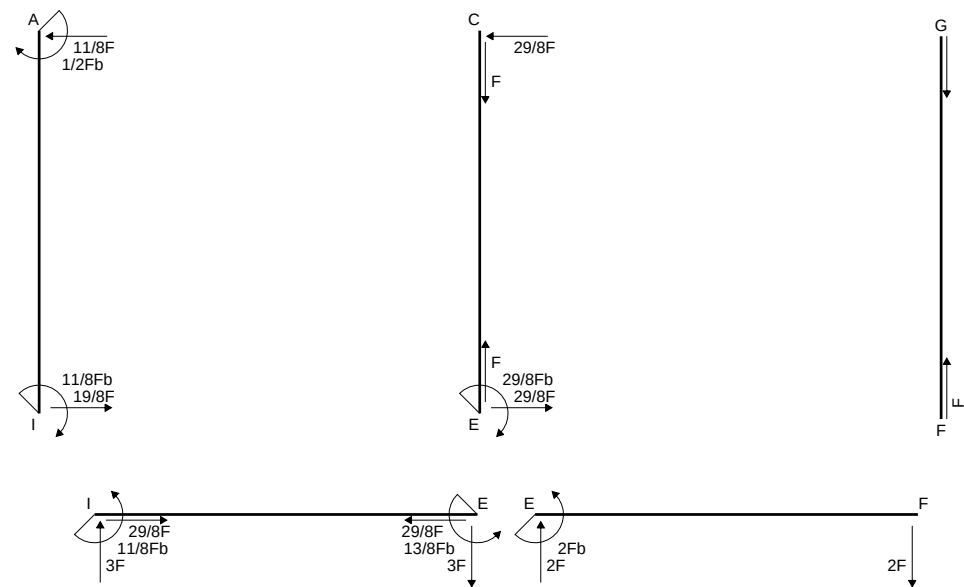
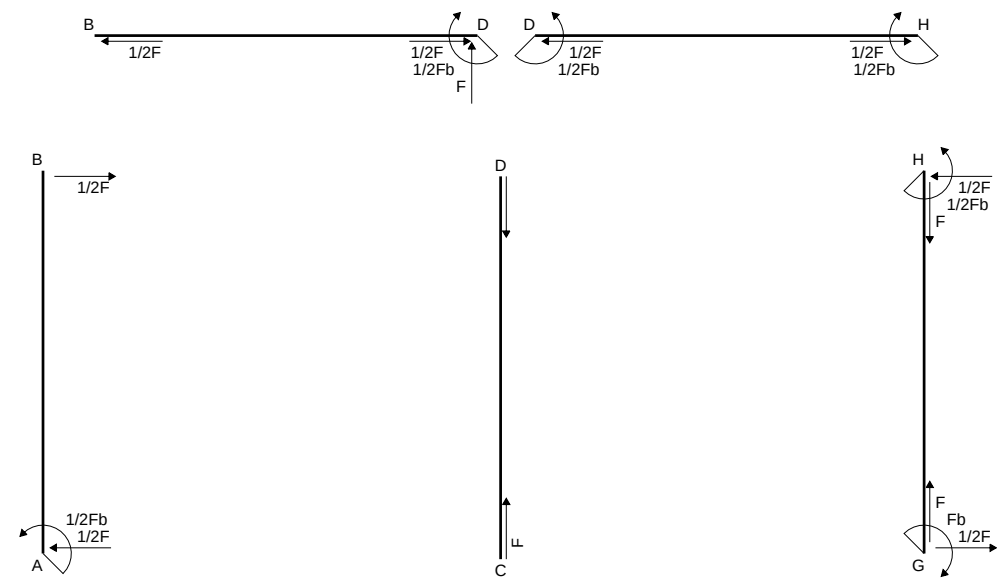


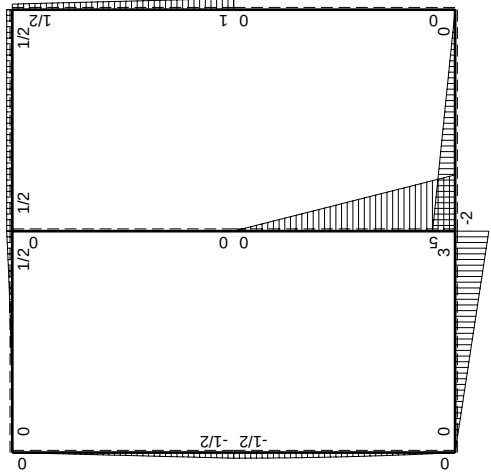
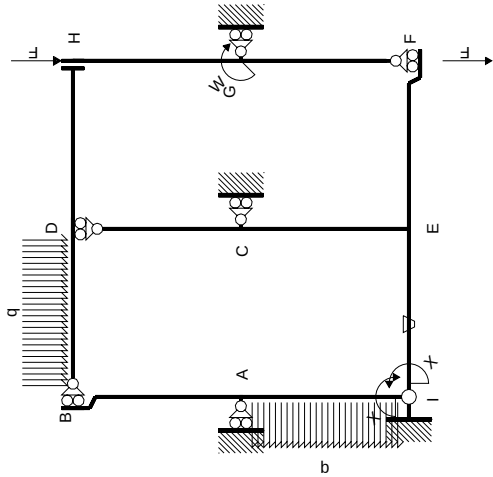
M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

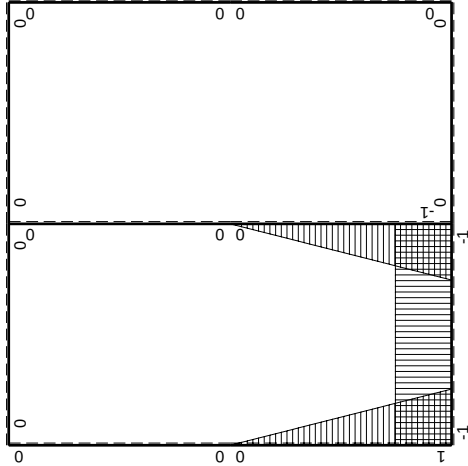
Sviluppi di calcolo iperstatica





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

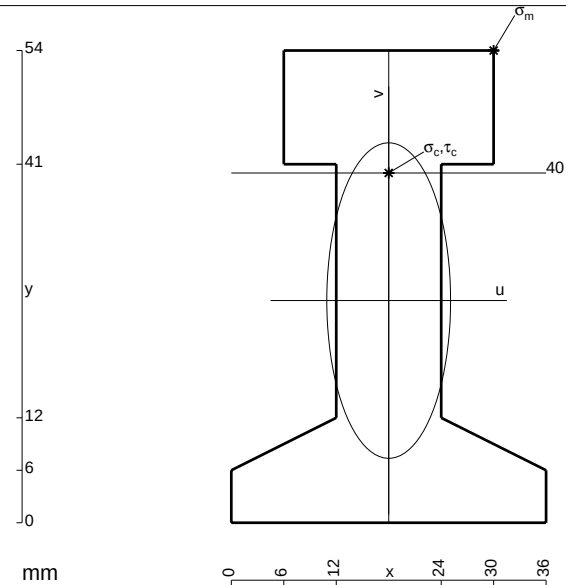
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

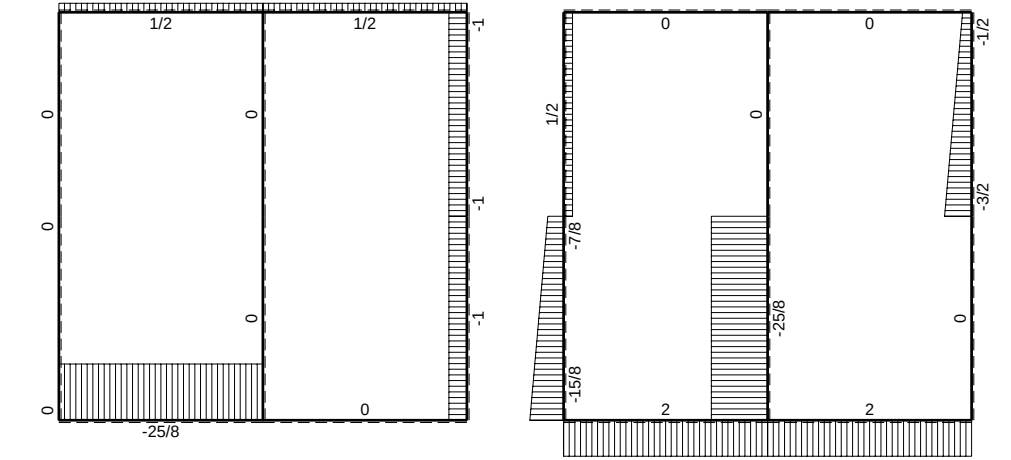
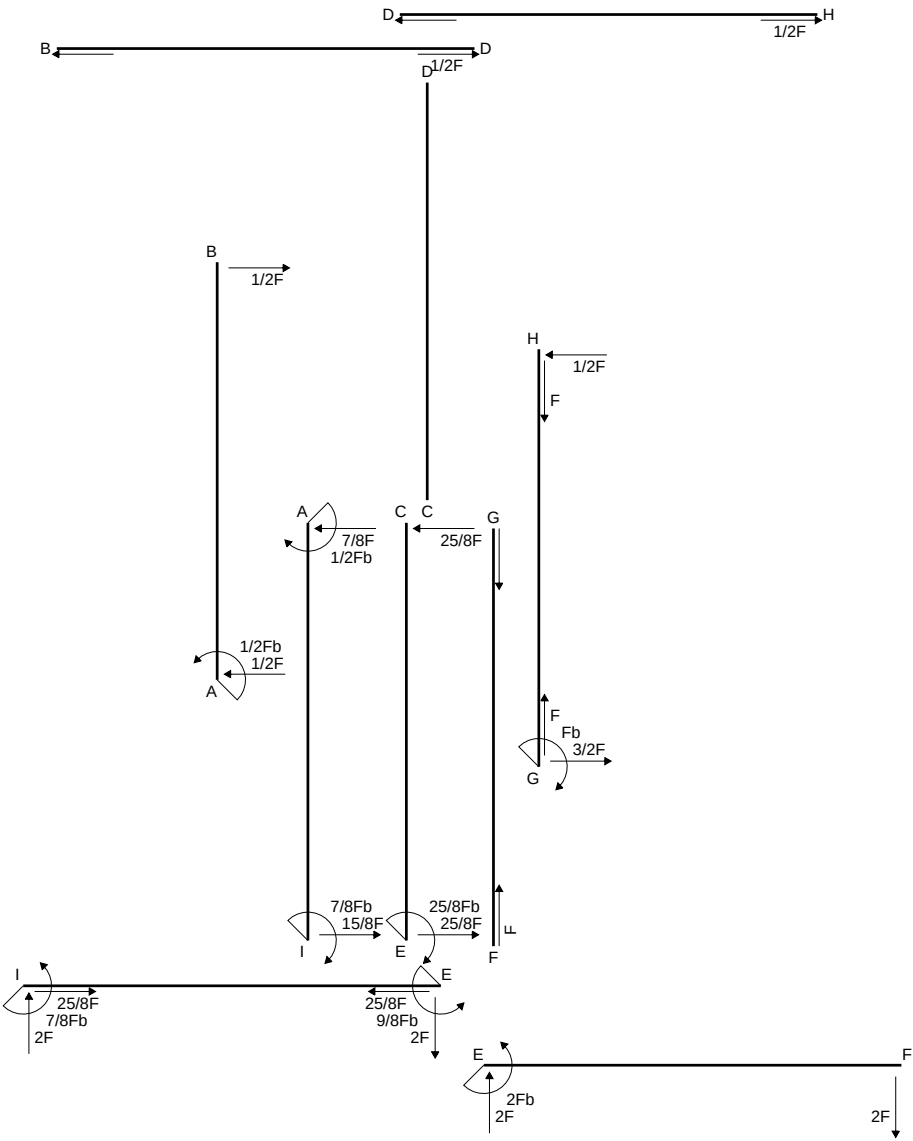
$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

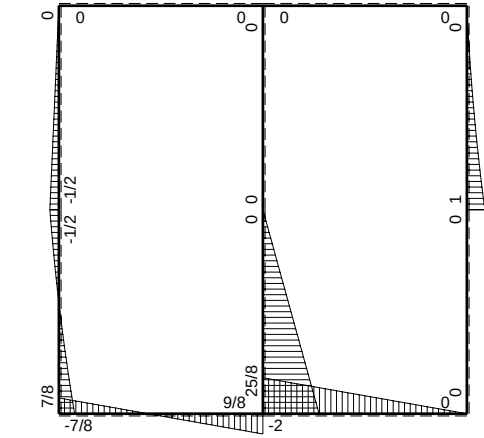


$$\begin{aligned} A &= 1020. \text{ mm}^2 \\ J_u &= 332140. \text{ mm}^4 \\ J_v &= 51120. \text{ mm}^4 \\ y_g &= 25.41 \text{ mm} \\ T_y &= 3800. \text{ N} \\ M_x &= -2660000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.59 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229. \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 14.59 \text{ mm} \\ \sigma_c &= -Mv/J_u = 116.9 \text{ N/mm}^2 \\ \tau_c &= 6.745 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 117.5 \text{ N/mm}^2 \\ S &= 7074. \text{ mm}^3 \end{aligned}$$

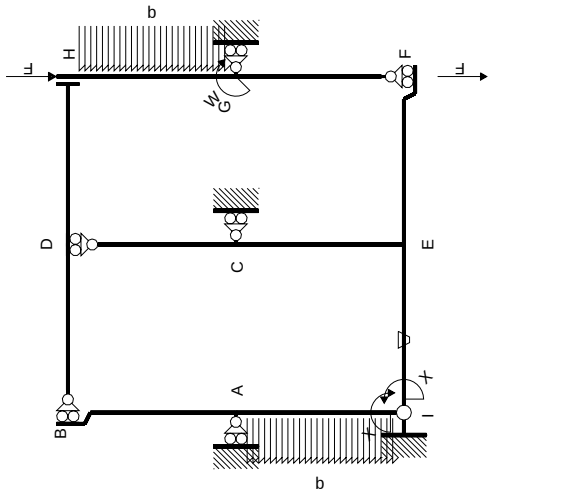


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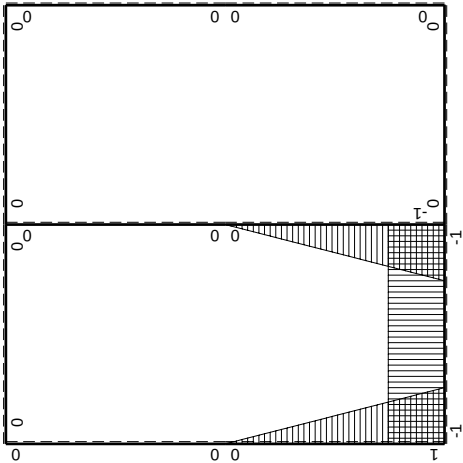


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fb+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

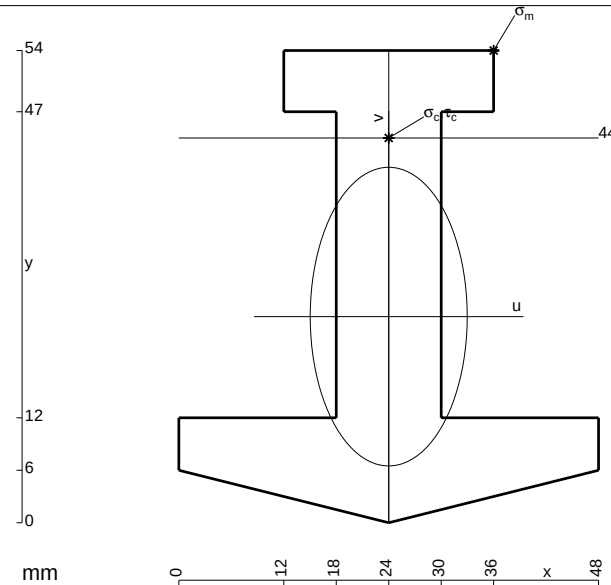
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 1020. \text{ mm}^2$$

$$J_u = 297608. \text{ mm}^4$$

$$J_v = 82224. \text{ mm}^4$$

$$y_g = 23.57 \text{ mm}$$

$$T_y = 3120. \text{ N}$$

$$M_x = -2340000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.43 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239.3 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

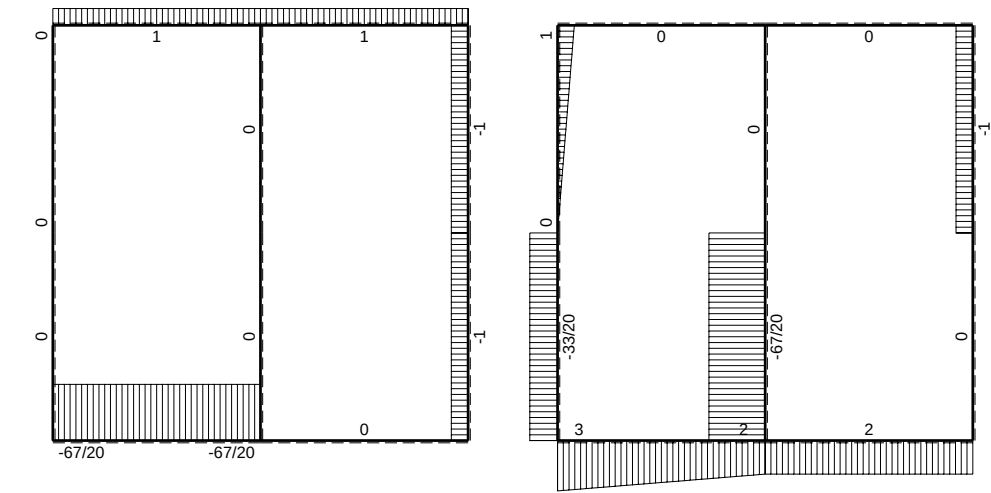
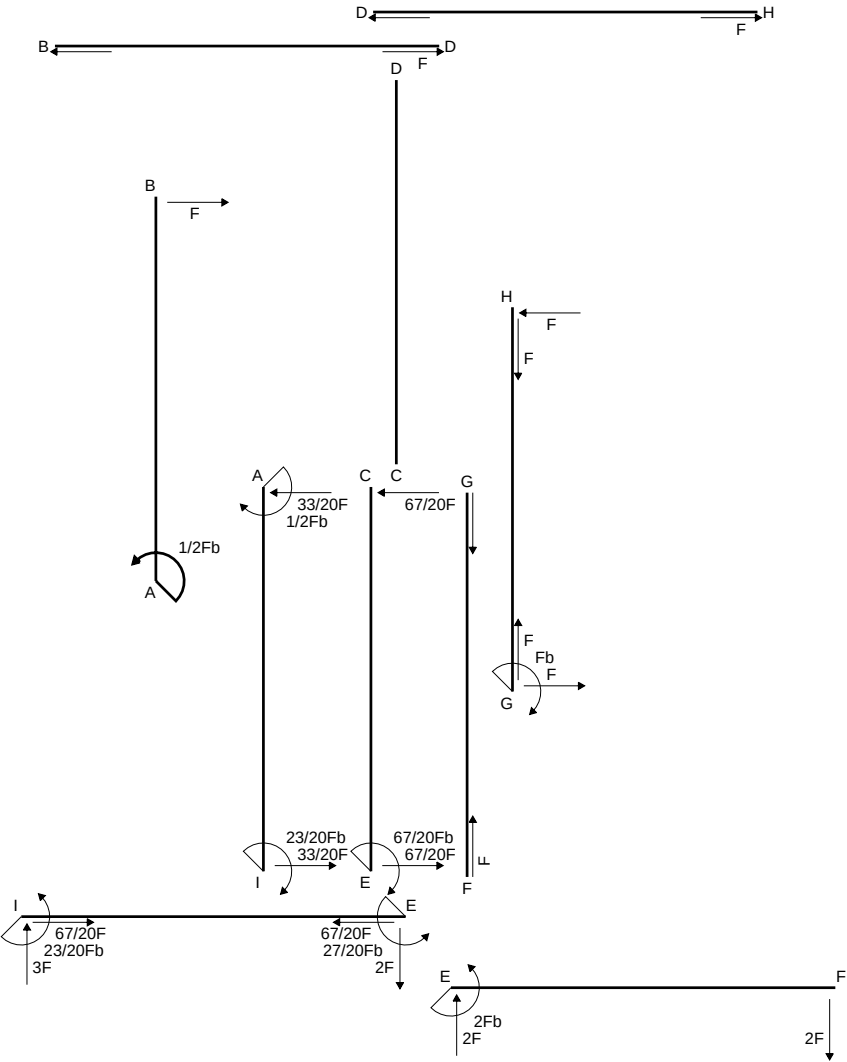
$$v_c = 20.43 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 160.6 \text{ N/mm}^2$$

$$\tau_c = 4.642 \text{ N/mm}^2$$

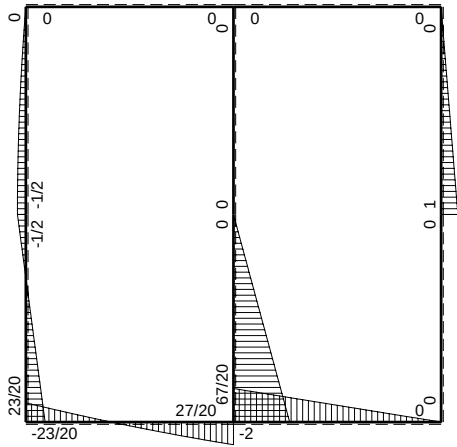
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 160.8 \text{ N/mm}^2$$

$$S = 5314. \text{ mm}^3$$



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Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

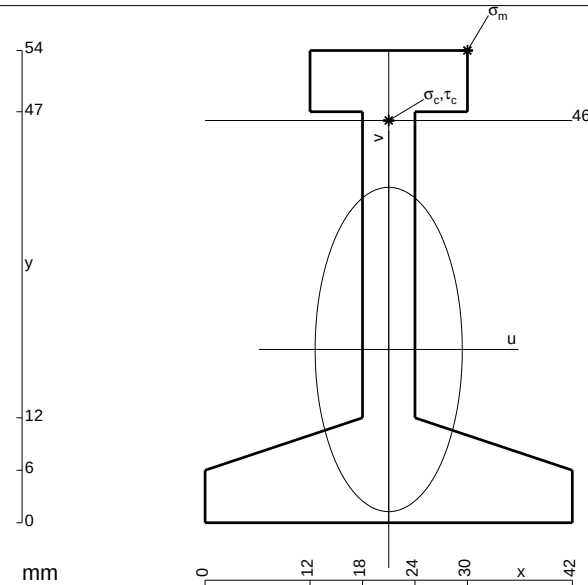
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 732. \text{ mm}^2$$

$$J_u = 251906. \text{ mm}^4$$

$$J_v = 51876. \text{ mm}^4$$

$$y_g = 19.81 \text{ mm}$$

$$T_y = 1800. \text{ N}$$

$$M_x = -1458000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 34.19 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 197.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

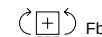
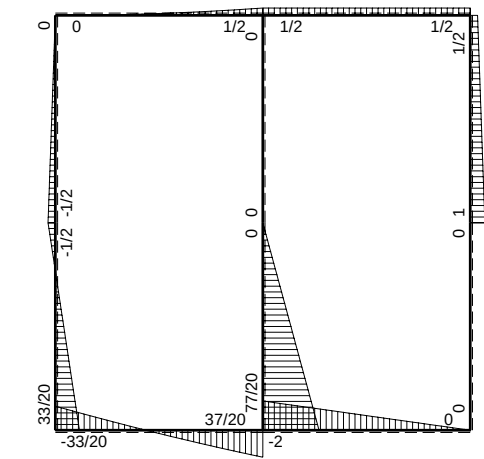
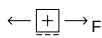
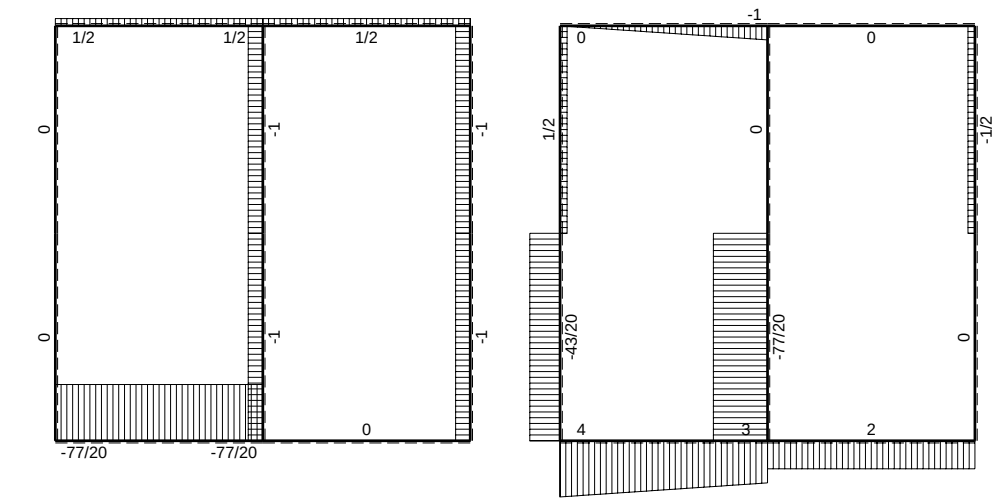
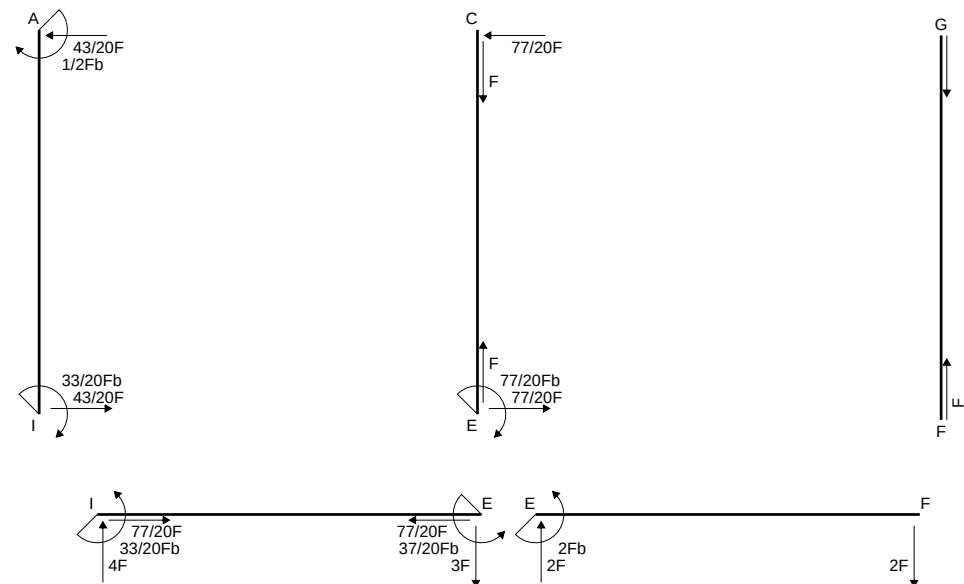
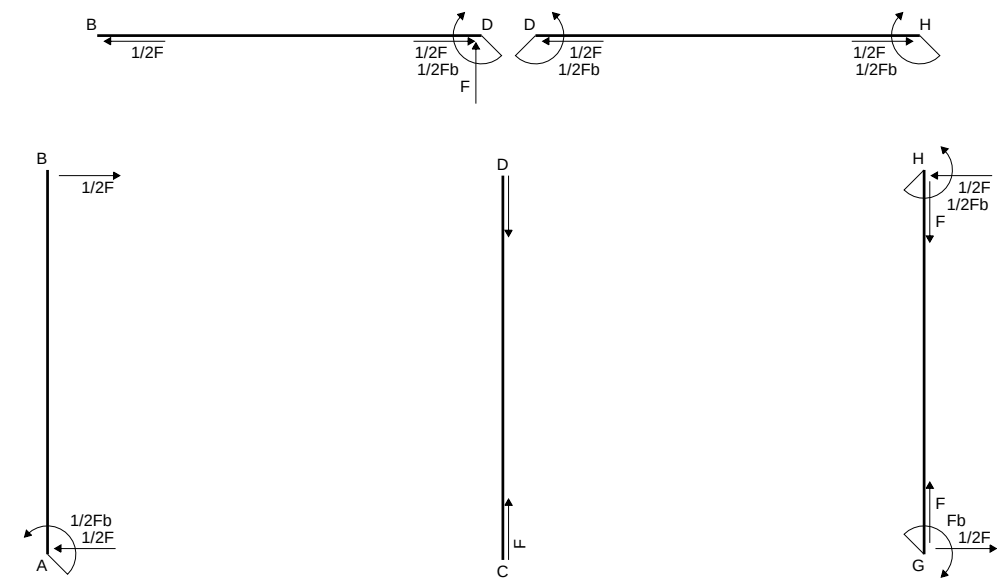
$$v_c = 26.19 \text{ mm}$$

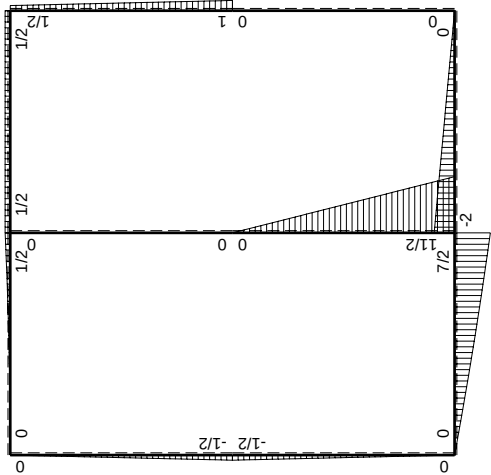
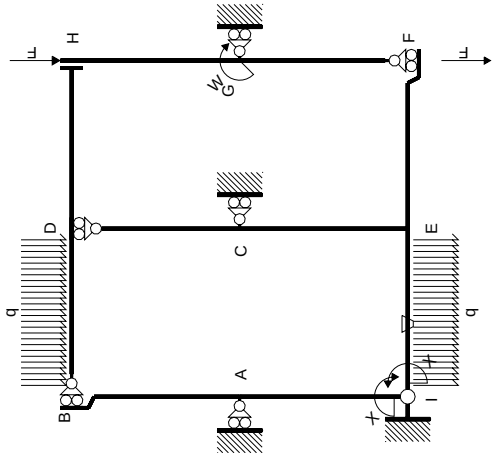
$$\sigma_c = -Mv/J_u = 151.6 \text{ N/mm}^2$$

$$\tau_c = 4.796 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 151.8 \text{ N/mm}^2$$

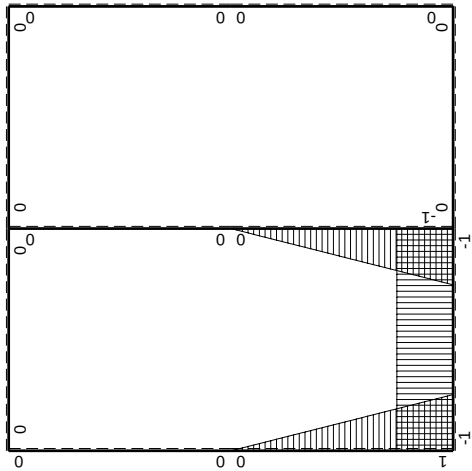
$$S = 4027. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

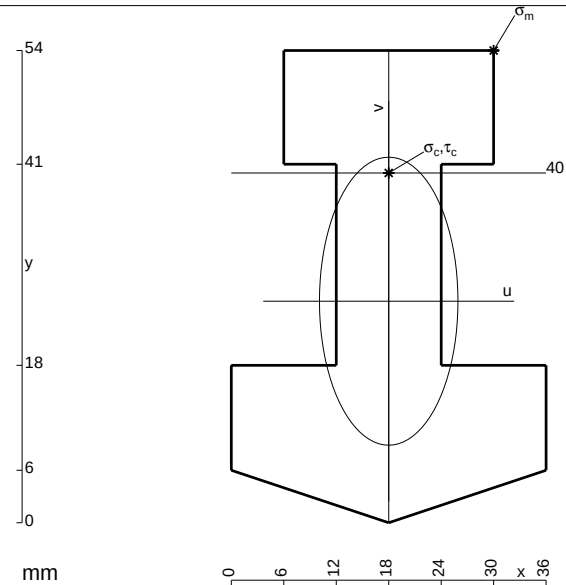
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1128. \text{ mm}^2$$

$$J_u = 306009. \text{ mm}^4$$

$$J_v = 70776. \text{ mm}^4$$

$$y_g = 25.34 \text{ mm}$$

$$T_y = 2600. \text{ N}$$

$$M_x = -2236000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.66 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.5 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

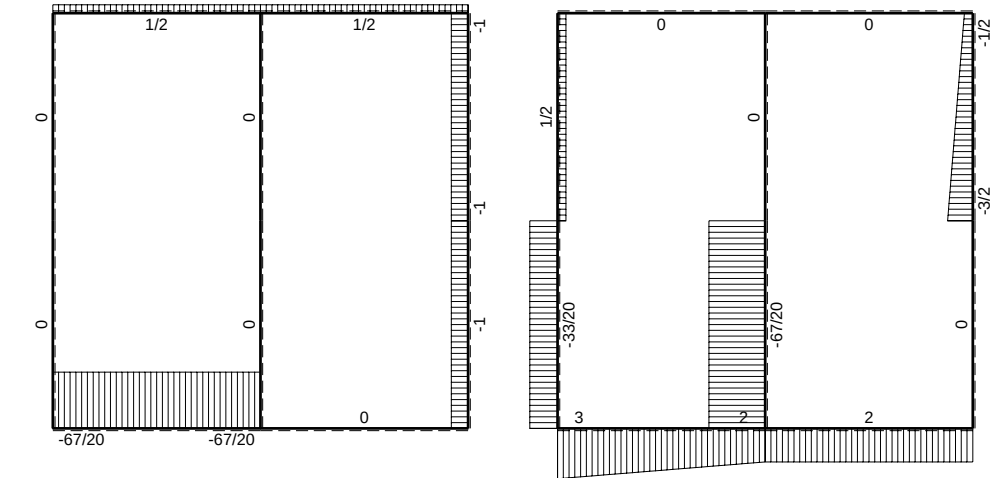
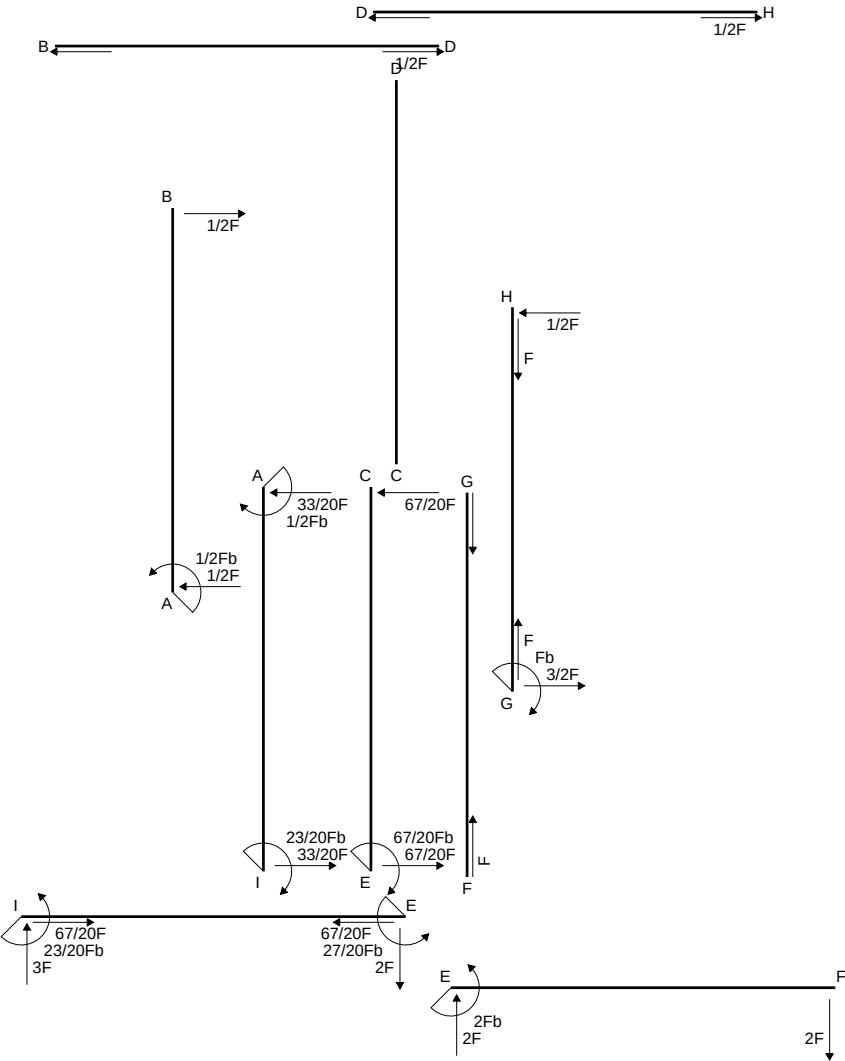
$$v_c = 14.66 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 107.2 \text{ N/mm}^2$$

$$\tau_c = 5.025 \text{ N/mm}^2$$

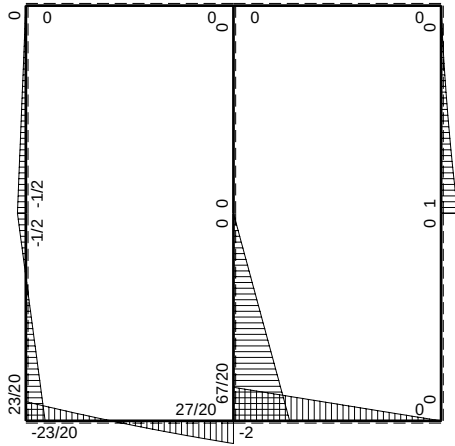
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 107.5 \text{ N/mm}^2$$

$$S = 7097. \text{ mm}^3$$

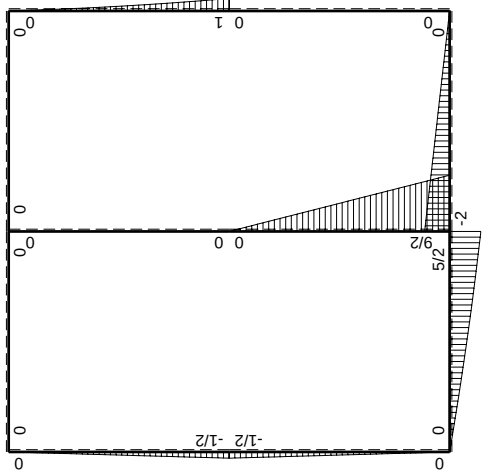
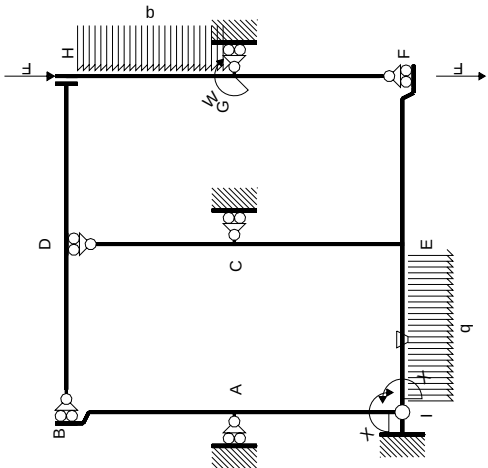


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

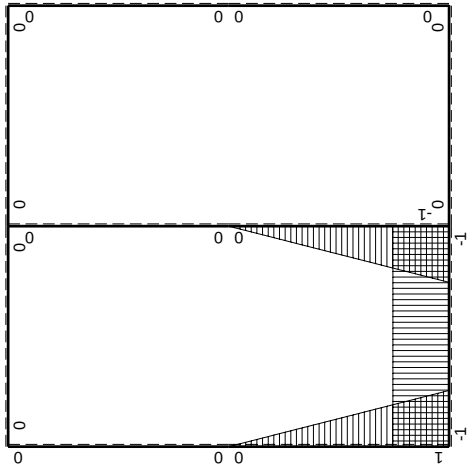


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

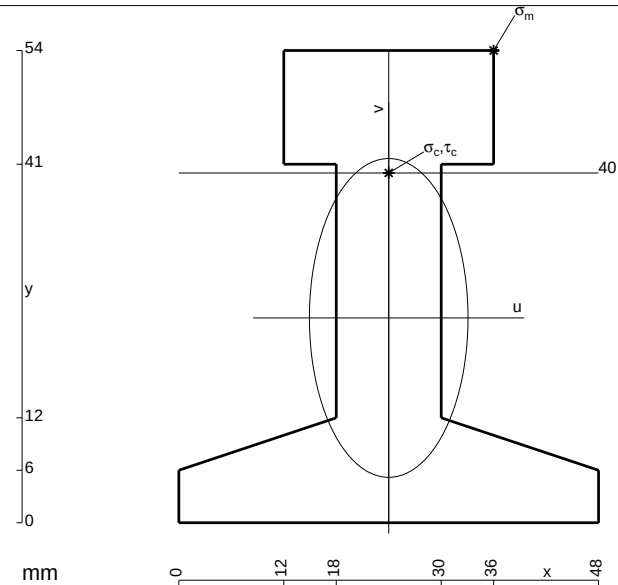
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1128. \text{ mm}^2$$

$$J_u = 375033. \text{ mm}^4$$

$$J_v = 92808. \text{ mm}^4$$

$$y_g = 23.42 \text{ mm}$$

$$T_y = 2960. \text{ N}$$

$$M_x = -2693600. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.58 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

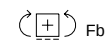
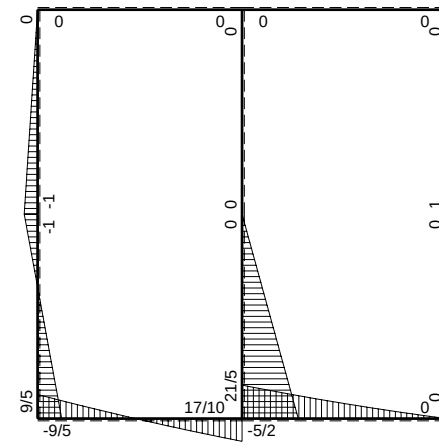
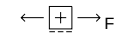
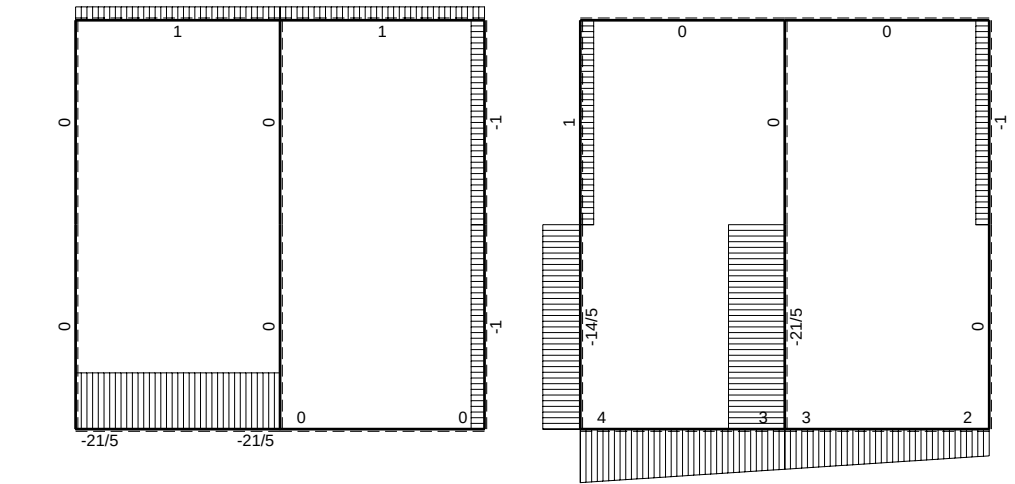
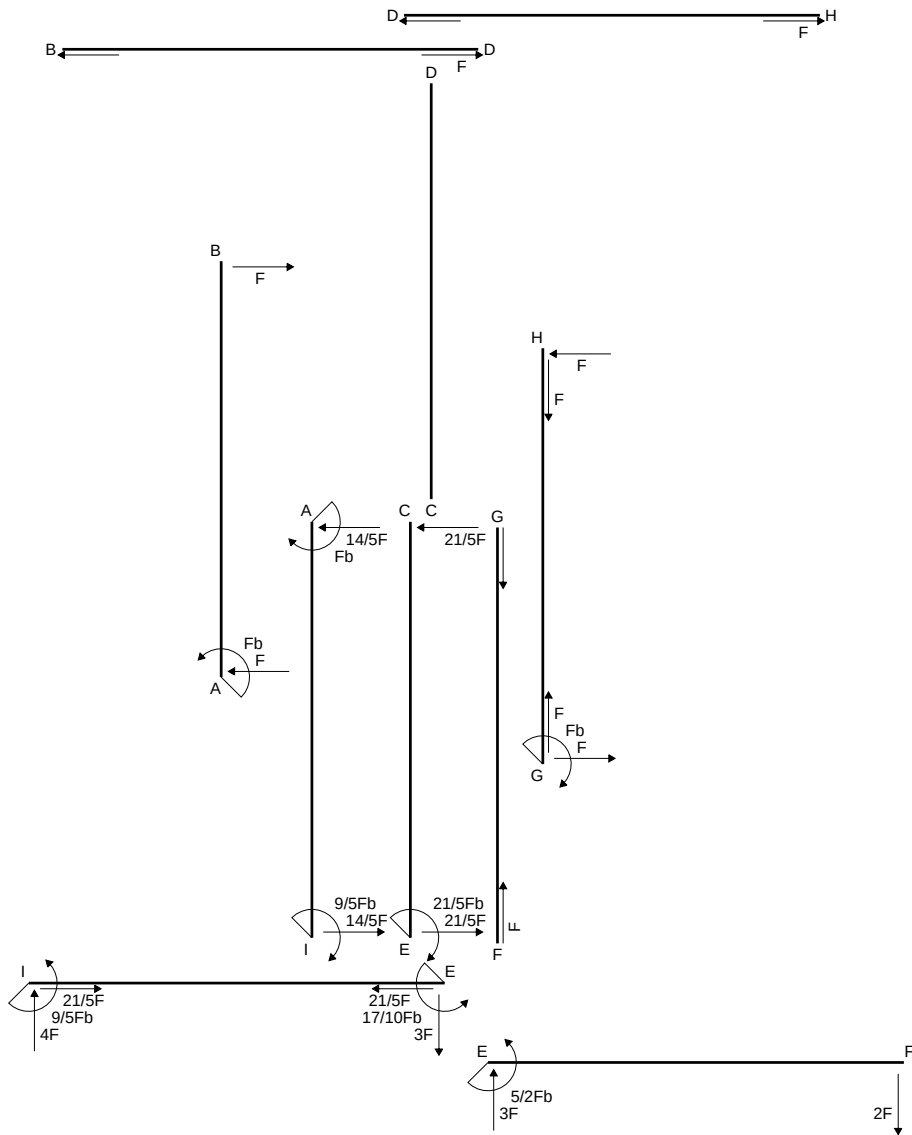
$$v_c = 16.58 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 119.1 \text{ N/mm}^2$$

$$\tau_c = 5.076 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 119.4 \text{ N/mm}^2$$

$$S = 7718. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	-Fb/EJ	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

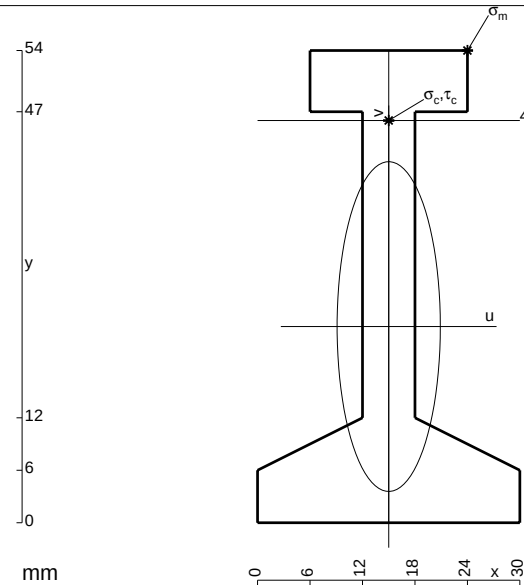
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 624. \text{ mm}^2$$

$$J_u = 221959. \text{ mm}^4$$

$$J_v = 21744. \text{ mm}^4$$

$$y_g = 22.43 \text{ mm}$$

$$T_y = 1980. \text{ N}$$

$$M_x = -1600500. \text{ Nmm}$$

$$x_m = 24. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 31.57 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 227.6 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

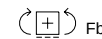
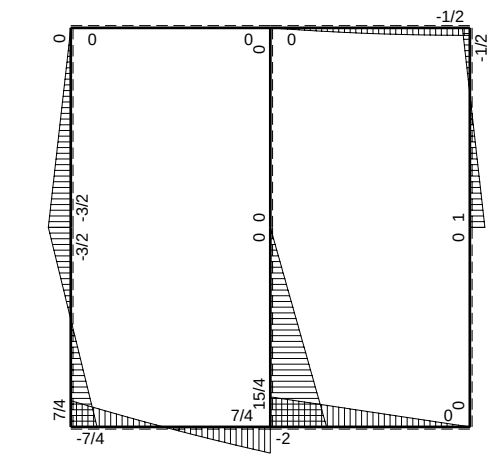
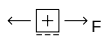
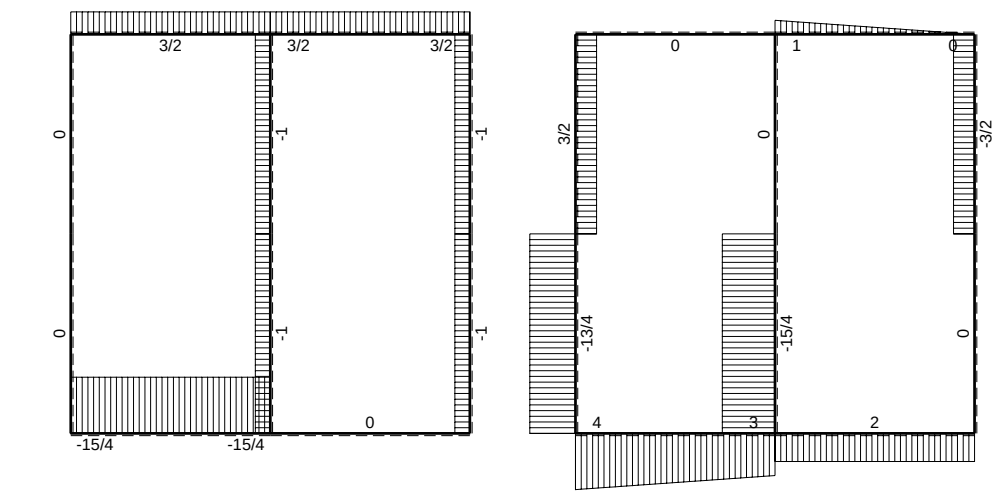
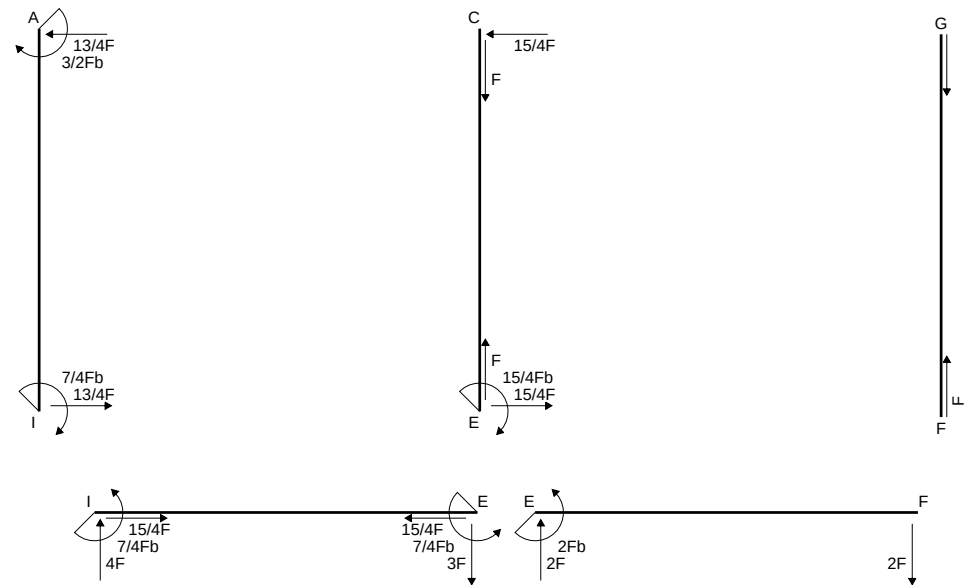
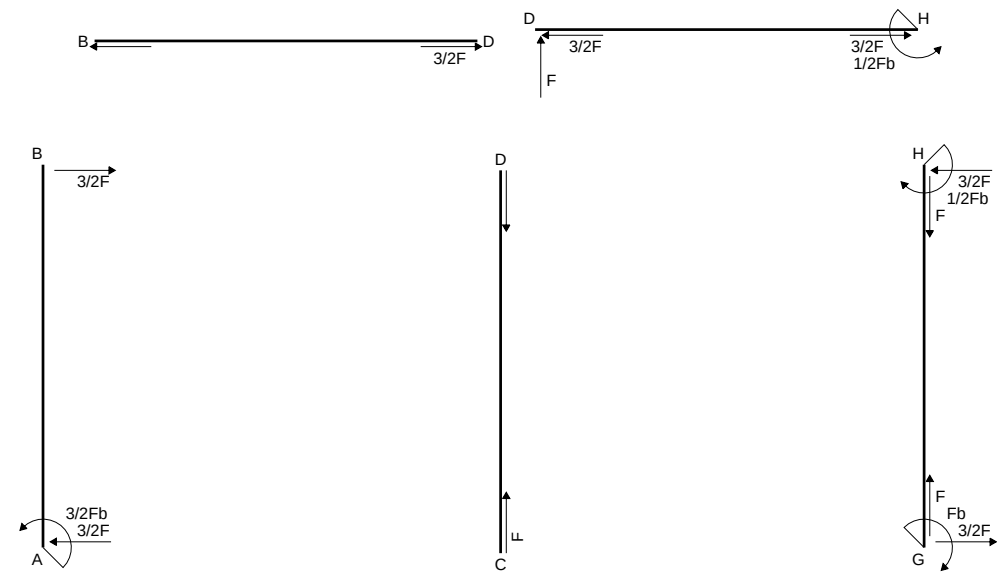
$$v_c = 23.57 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 169.9 \text{ N/mm}^2$$

$$\tau_c = 5.473 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 170.2 \text{ N/mm}^2$$

$$S = 3681. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

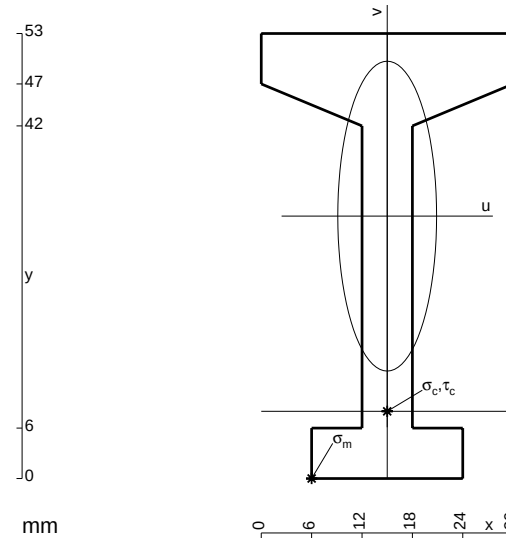
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 594. \text{ mm}^2$$

$$J_u = 202331. \text{ mm}^4$$

$$J_v = 20574. \text{ mm}^4$$

$$y_g = 31.25 \text{ mm}$$

$$T_y = 1540. \text{ N}$$

$$M_x = -1540000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -31.25 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -237.9 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 31.25 \text{ mm}$$

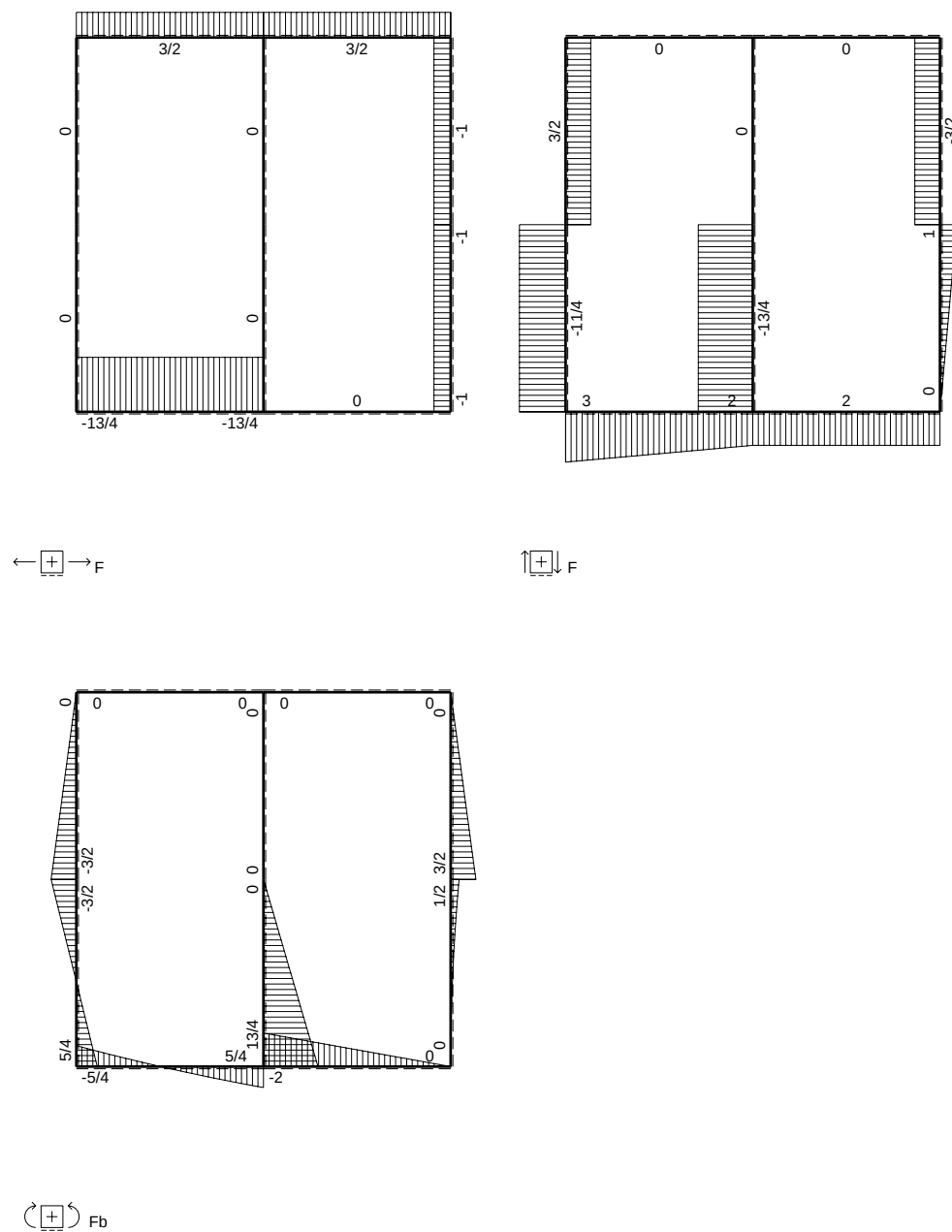
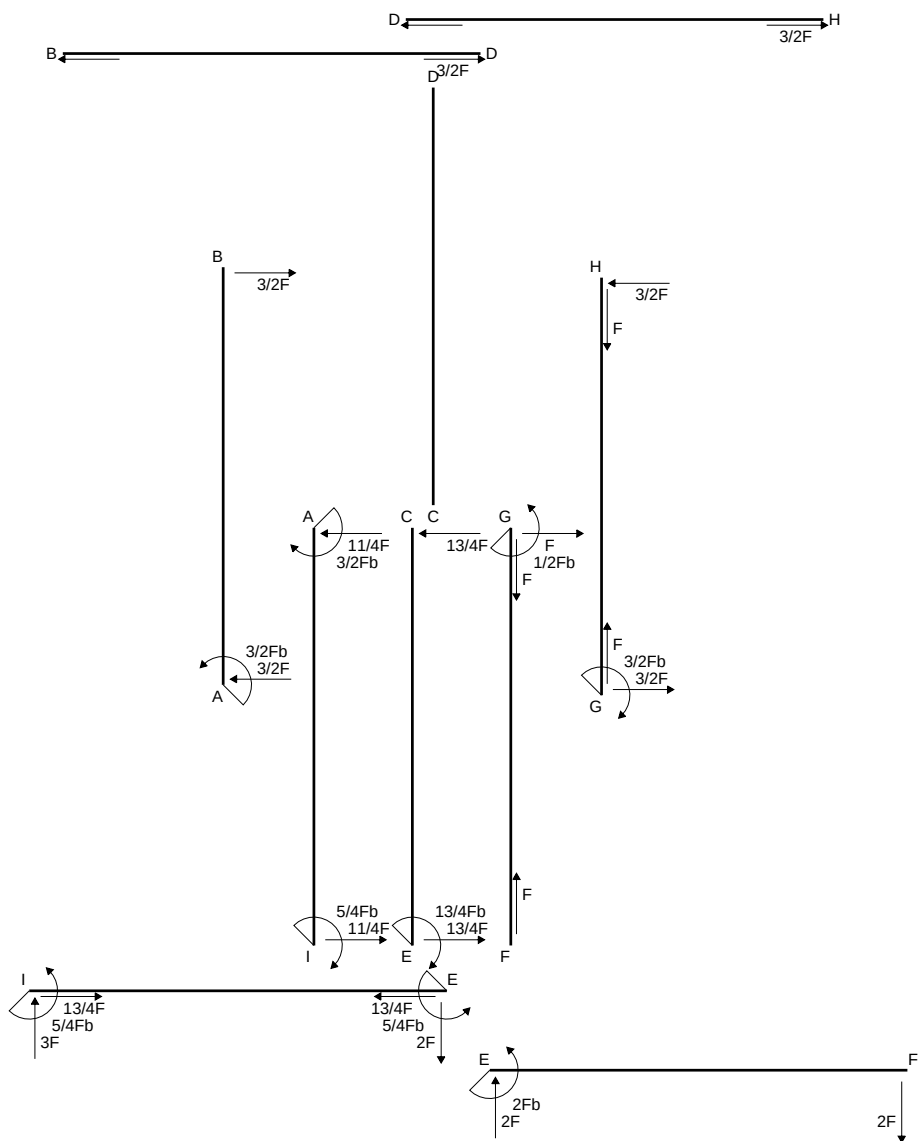
$$v_c = -23.25 \text{ mm}$$

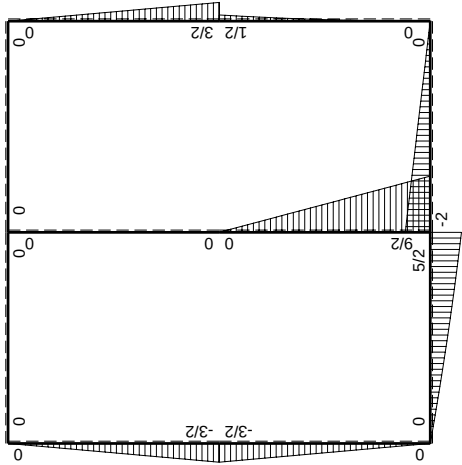
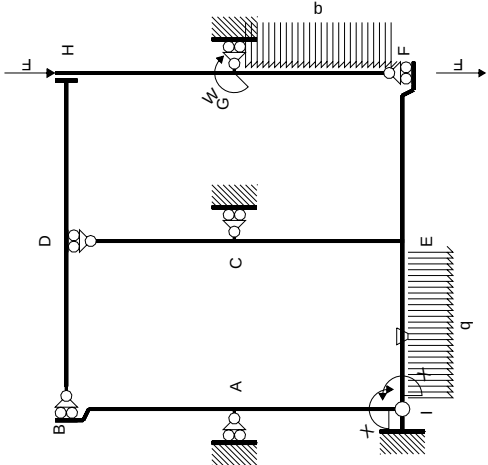
$$\sigma_c = -Mv/J_u = -177. \text{ N/mm}^2$$

$$\tau_c = 4.24 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 177.1 \text{ N/mm}^2$$

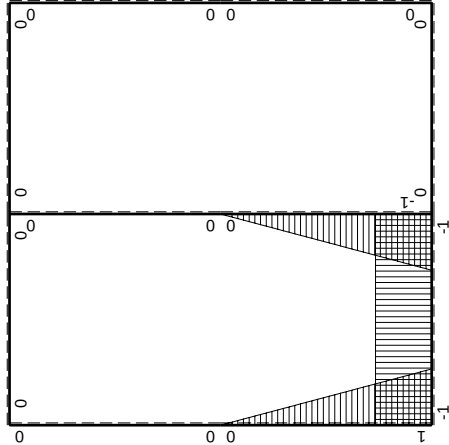
$$S = 3342. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

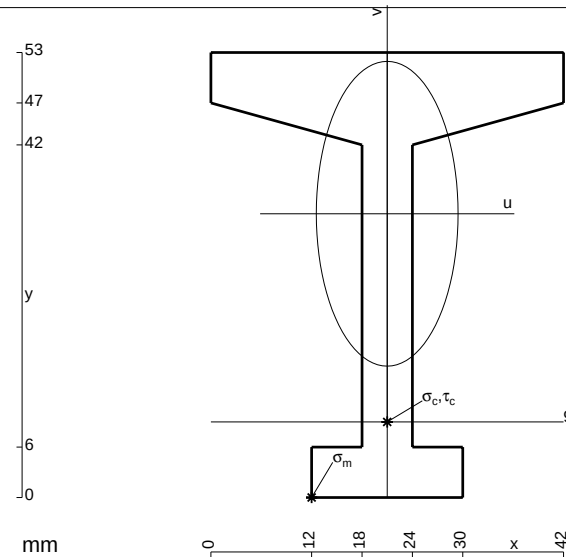
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

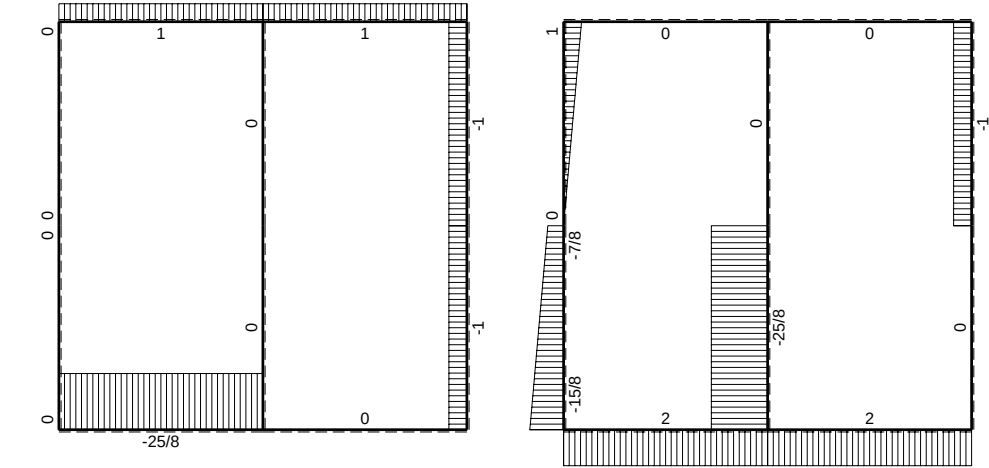
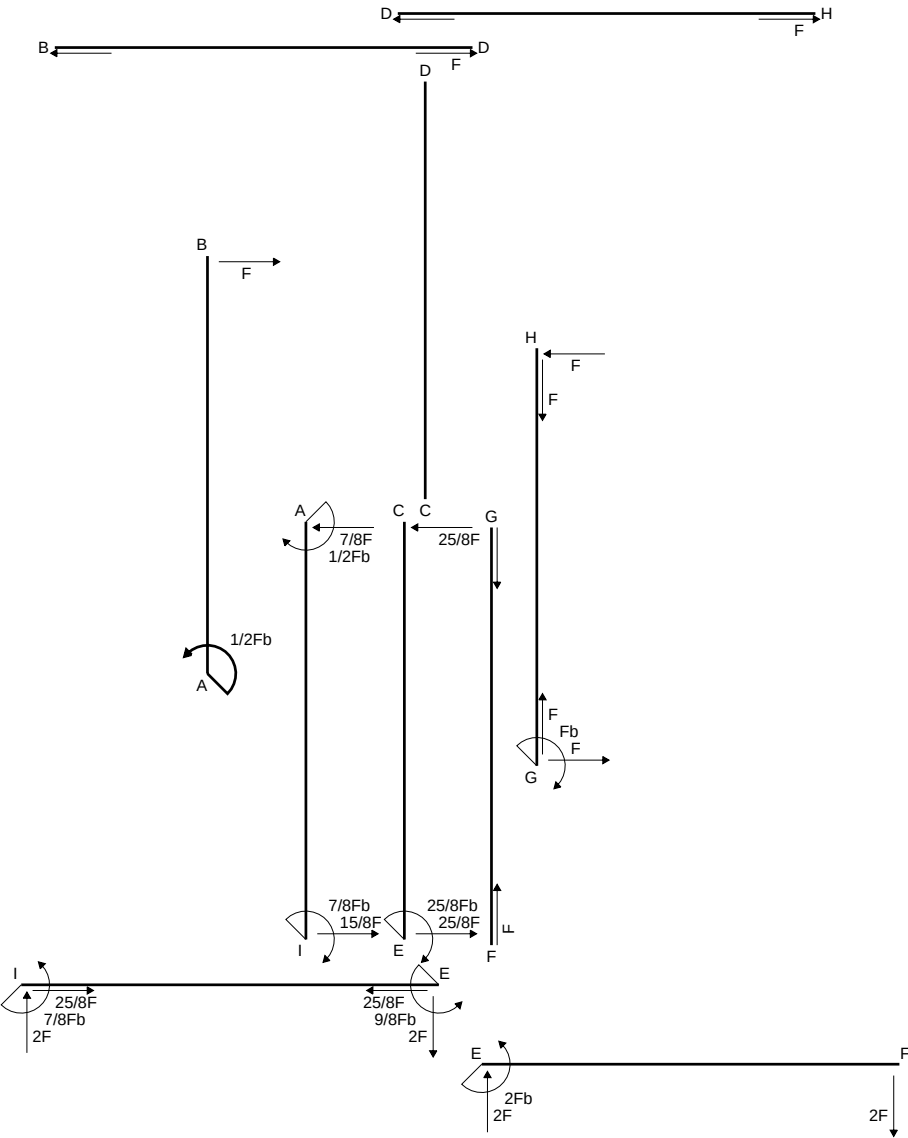
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

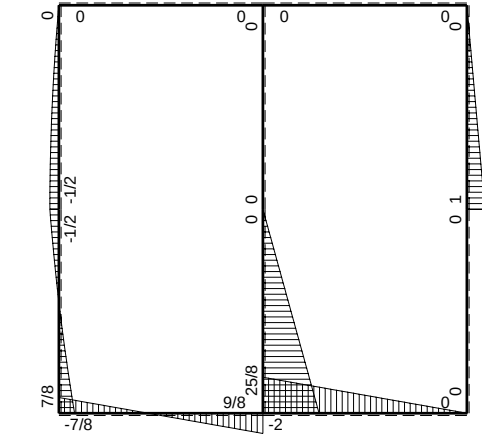


$$\begin{aligned} A &= 696. \text{ mm}^2 \\ J_u &= 229334. \text{ mm}^4 \\ J_v &= 49608. \text{ mm}^4 \\ y_g &= 33.8 \text{ mm} \\ T_y &= 2560. \text{ N} \\ M_x &= -1356800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -33.8 \text{ mm} \\ \sigma_m &= -Mv/J_u = -200. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -24.8 \text{ mm} \\ \sigma_c &= -Mv/J_u = -146.7 \text{ N/mm}^2 \\ \tau_c &= 7.069 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 147.2 \text{ N/mm}^2 \\ S &= 3799. \text{ mm}^3 \end{aligned}$$

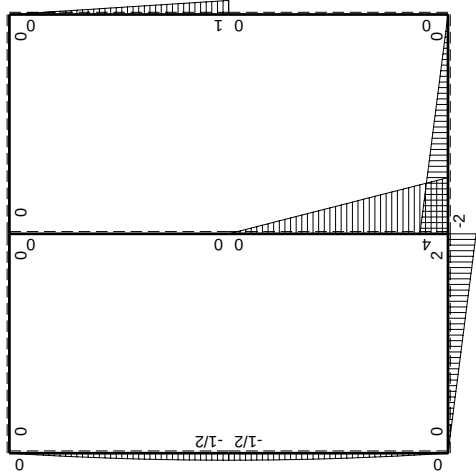
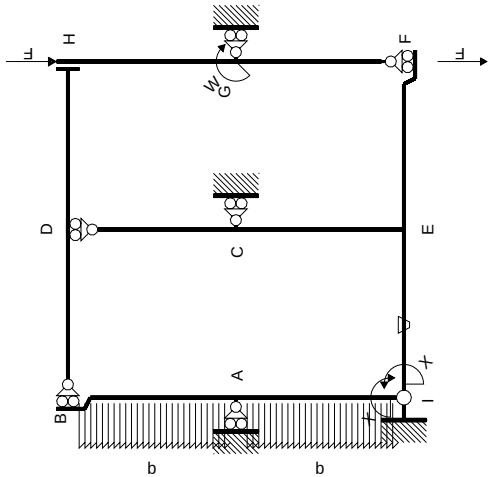


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

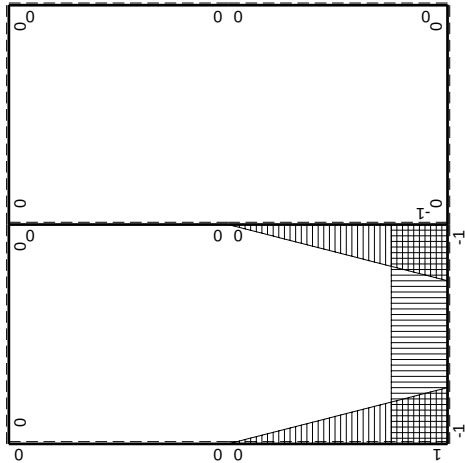


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

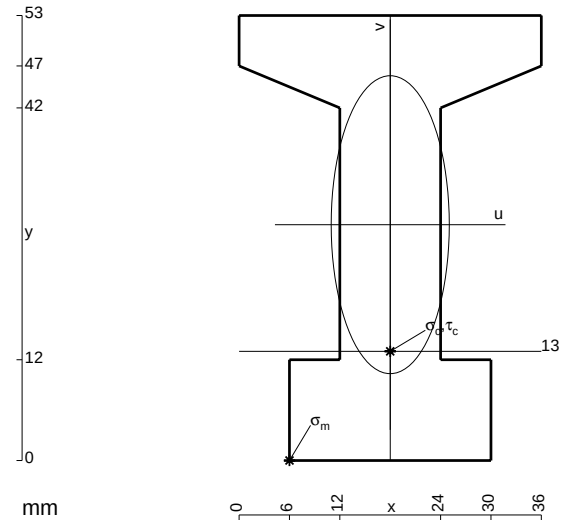
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 984. \text{ mm}^2$$

$$J_u = 309962. \text{ mm}^4$$

$$J_v = 48672. \text{ mm}^4$$

$$y_g = 28.09 \text{ mm}$$

$$T_y = 3980. \text{ N}$$

$$M_x = -2308400. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.09 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.2 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

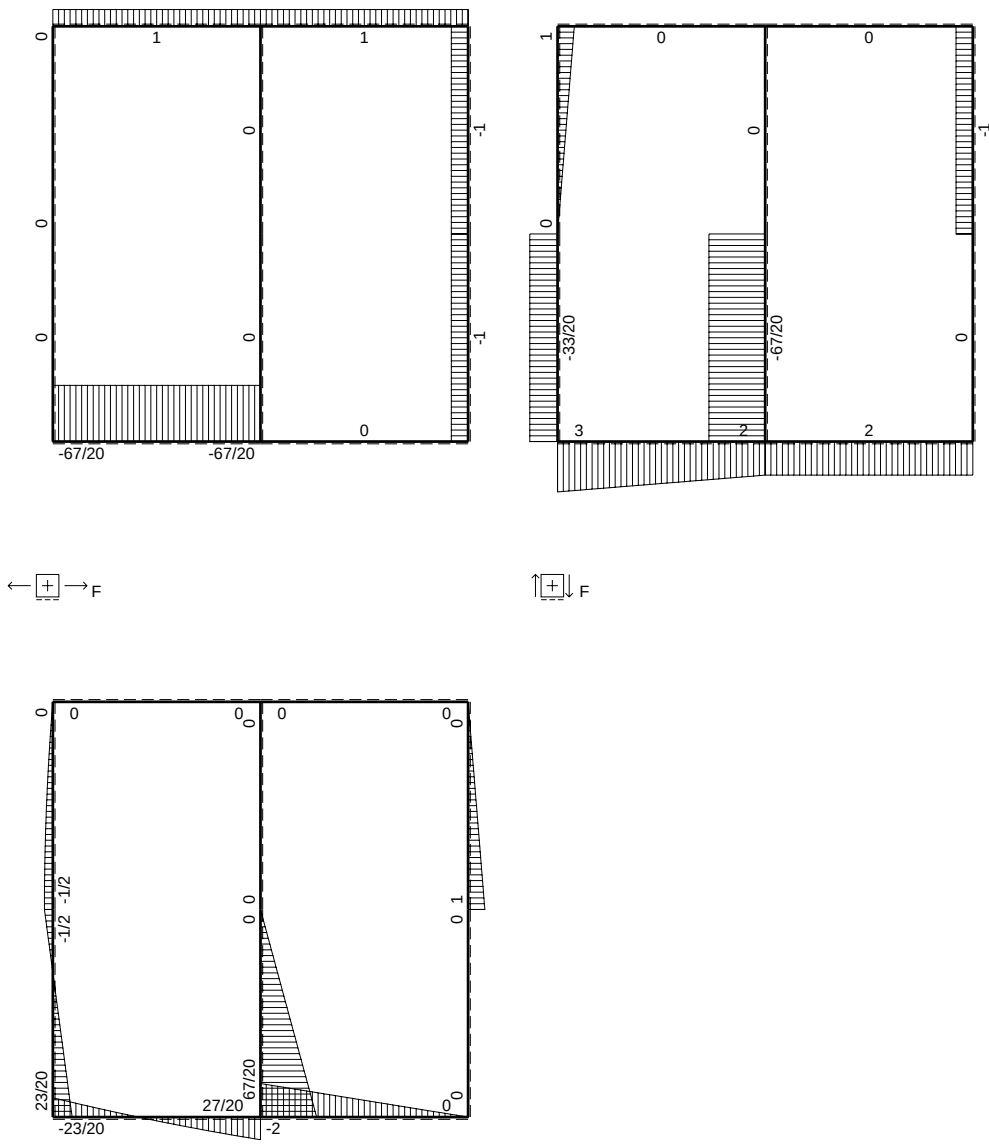
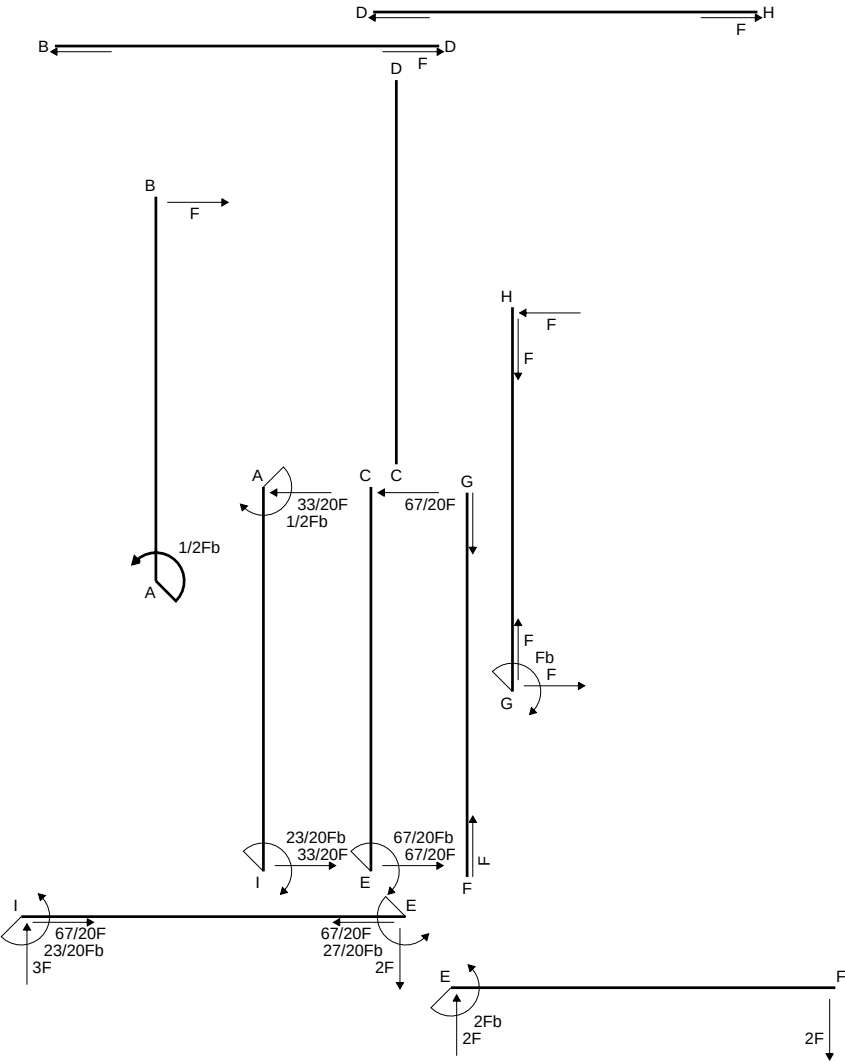
$$v_c = -15.09 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -112.4 \text{ N/mm}^2$$

$$\tau_c = 7.007 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 113. \text{ N/mm}^2$$

$$S^* = 6548. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

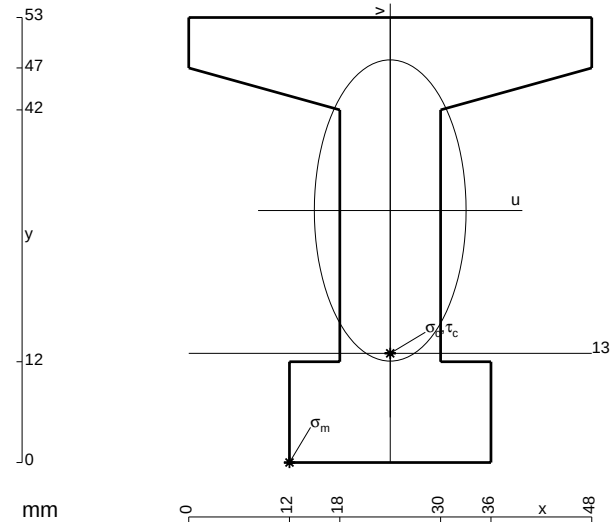
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1086. \text{ mm}^2$$

$$J_u = 349673. \text{ mm}^4$$

$$J_v = 88740. \text{ mm}^4$$

$$y_g = 30.02 \text{ mm}$$

$$T_y = 4060. \text{ N}$$

$$M_x = -2557800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.02 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

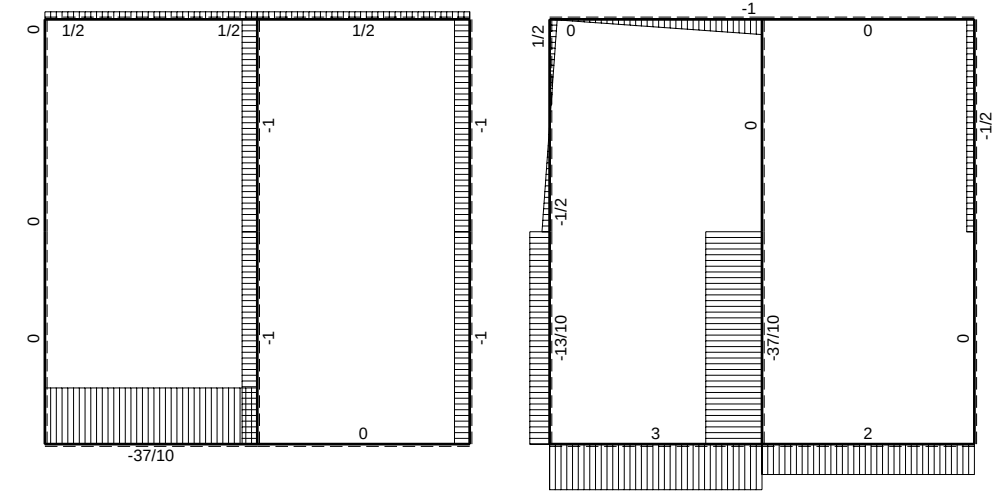
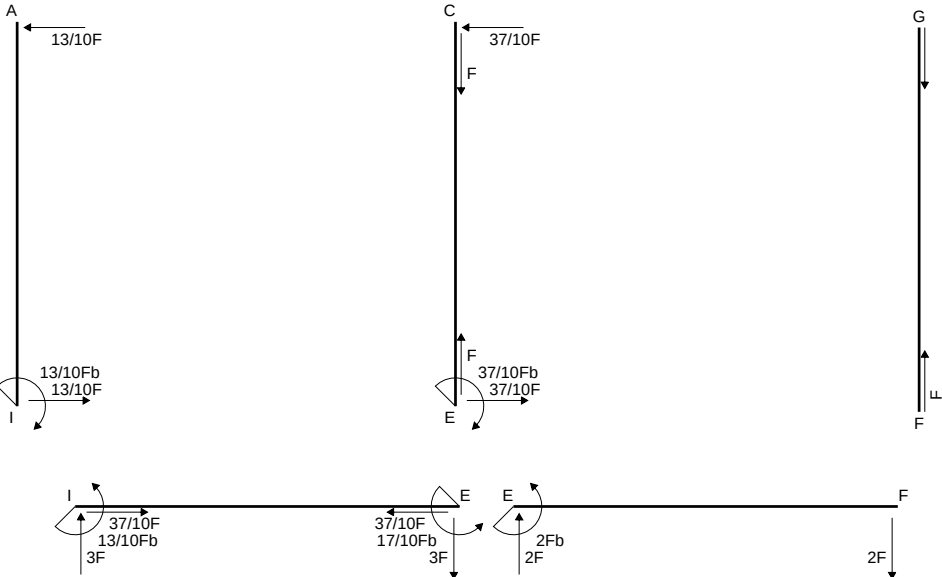
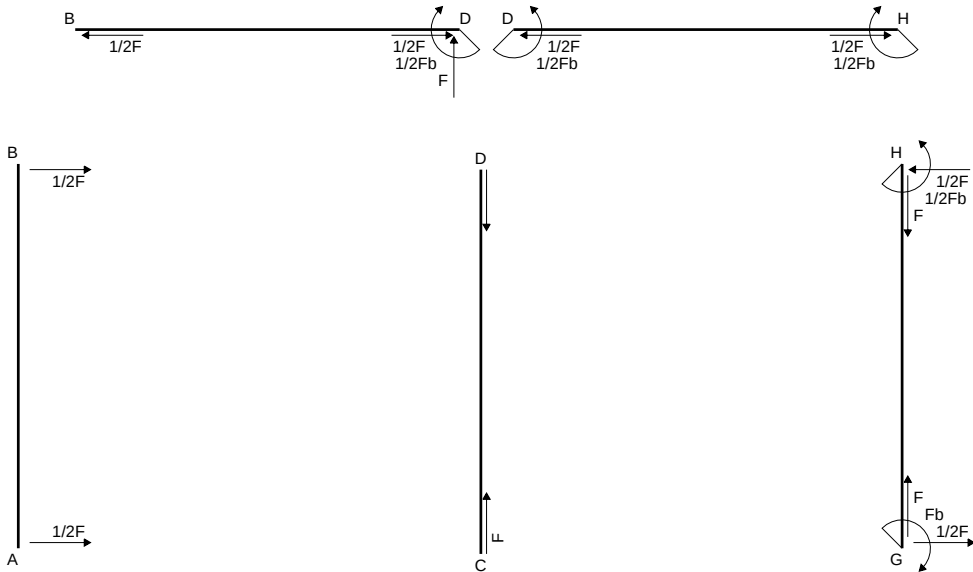
$$v_c = -17.02 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -124.5 \text{ N/mm}^2$$

$$\tau_c = 6.896 \text{ N/mm}^2$$

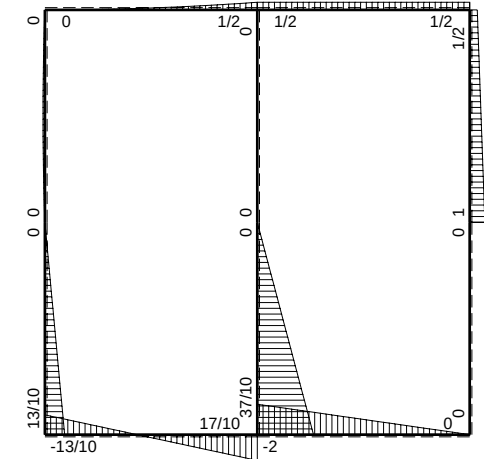
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 125. \text{ N/mm}^2$$

$$S^* = 7127. \text{ mm}^3$$

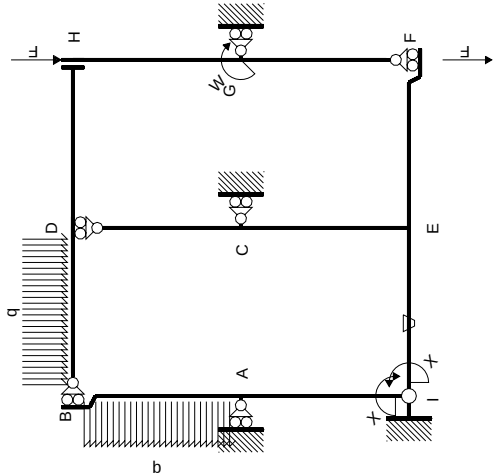


← ⊕ → F

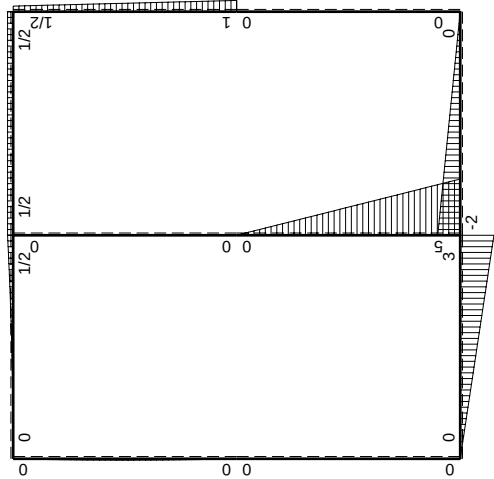
↑ ⊕ ↓ F



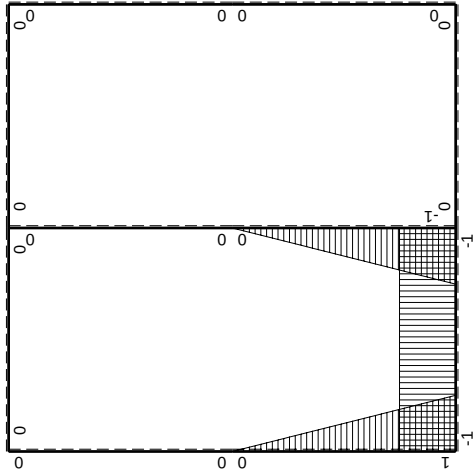
⊕ ⊖ Fb



Schema di calcolo iperstatico



M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

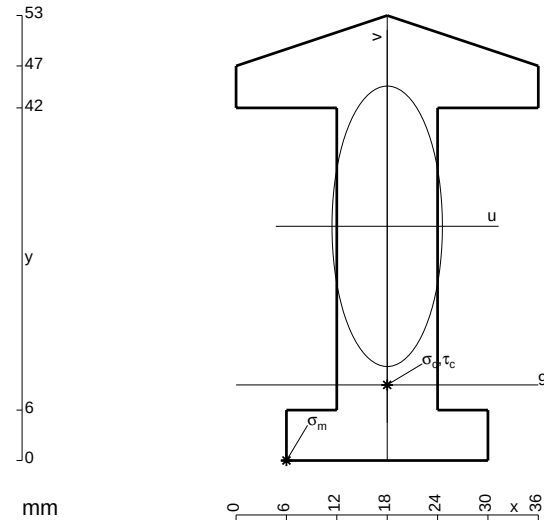
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$



$$A = 864. \text{ mm}^2$$

$$J_u = 241215. \text{ mm}^4$$

$$J_v = 37368. \text{ mm}^4$$

$$y_g = 27.9 \text{ mm}$$

$$T_y = 2920. \text{ N}$$

$$M_x = -1985600. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -27.9 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

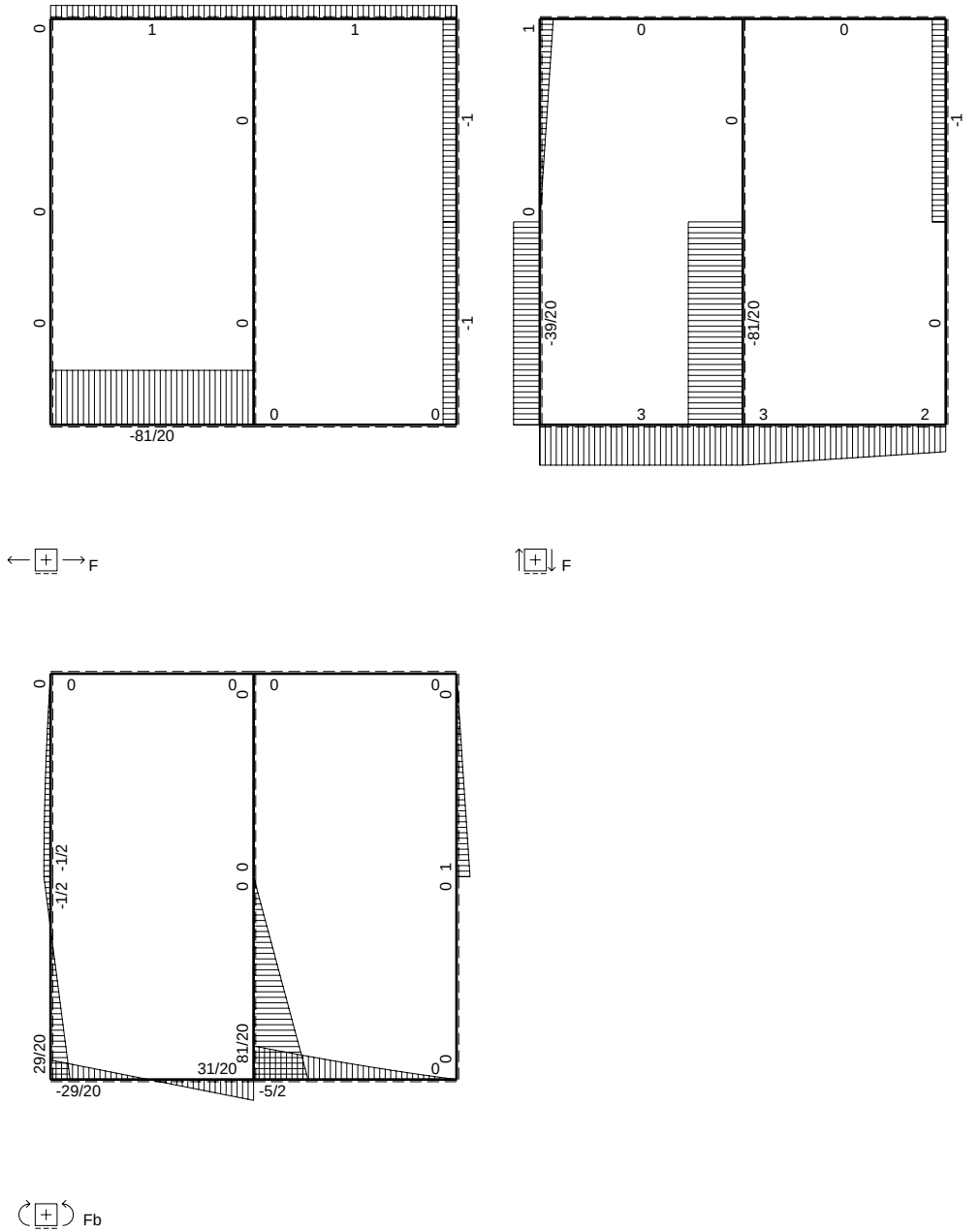
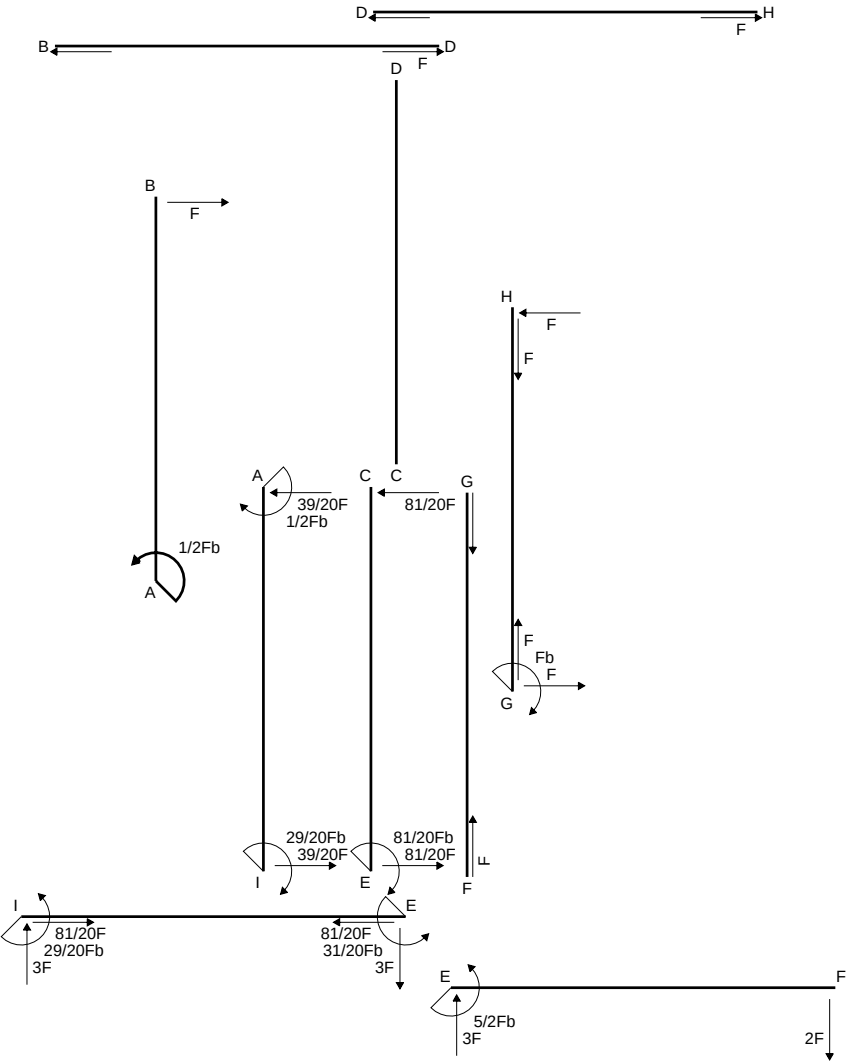
$$v_c = -18.9 \text{ mm}$$

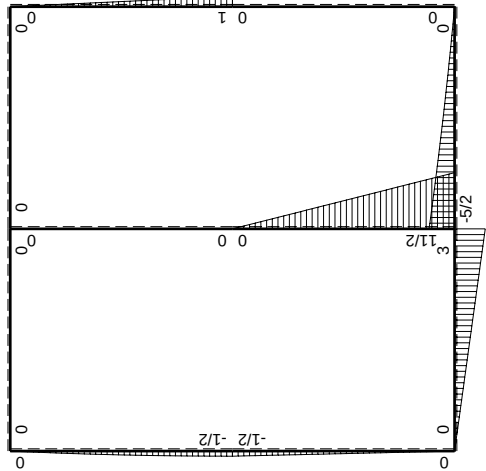
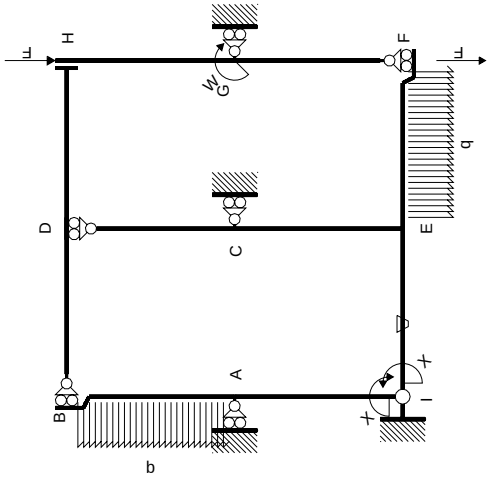
$$\sigma_c = -Mv/J_u = -155.5 \text{ N/mm}^2$$

$$\tau_c = 4.357 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 155.7 \text{ N/mm}^2$$

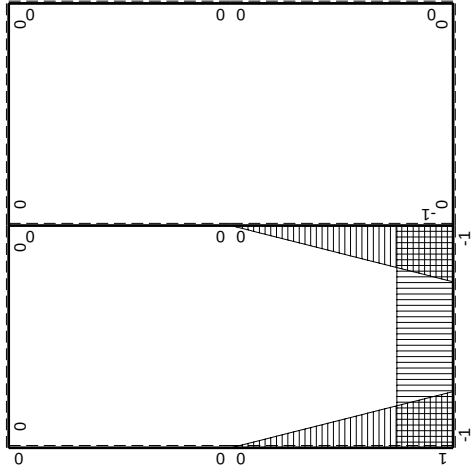
$$S = 4319. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

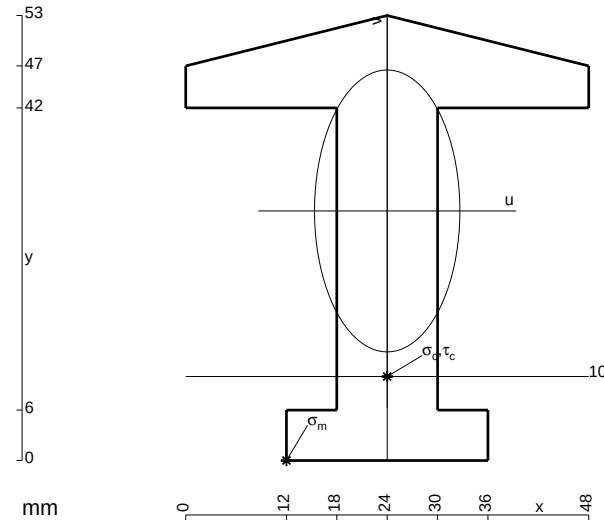
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 960. \text{ mm}^2$$

$$J_u = 270775. \text{ mm}^4$$

$$J_v = 72000. \text{ mm}^4$$

$$y_g = 29.73 \text{ mm}$$

$$T_y = 3540. \text{ N}$$

$$M_x = -2183000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.73 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

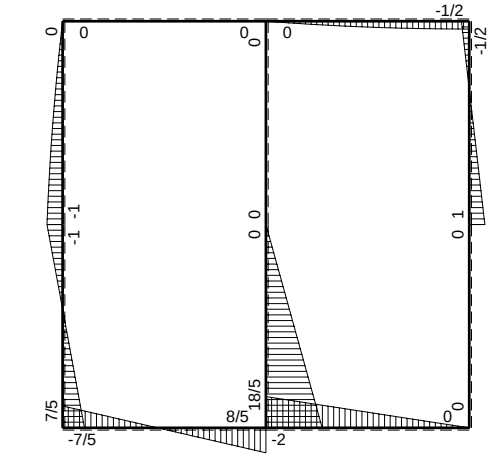
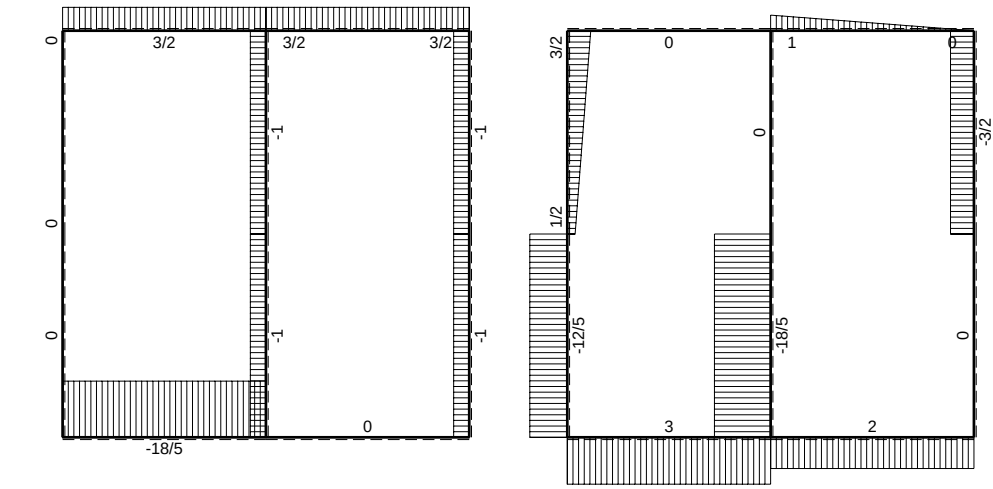
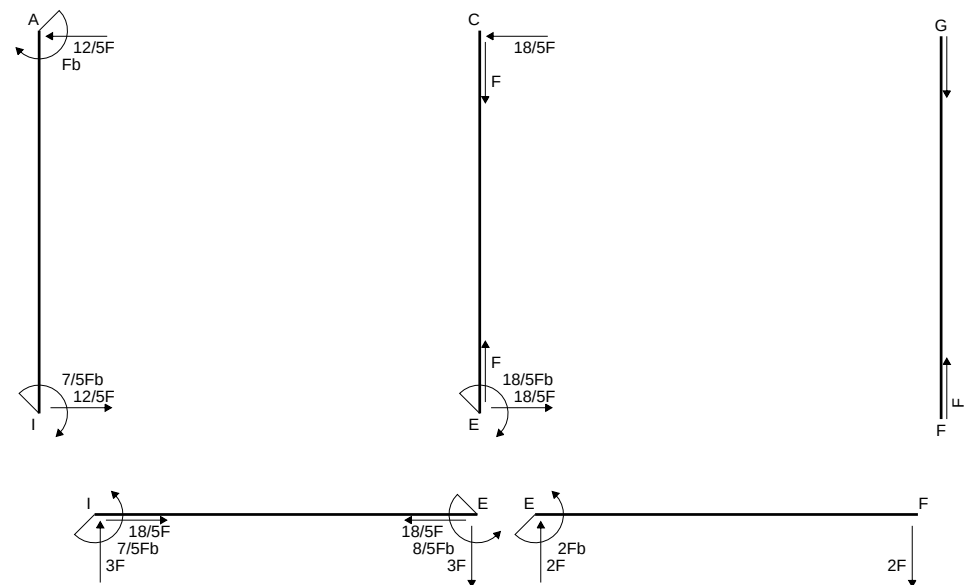
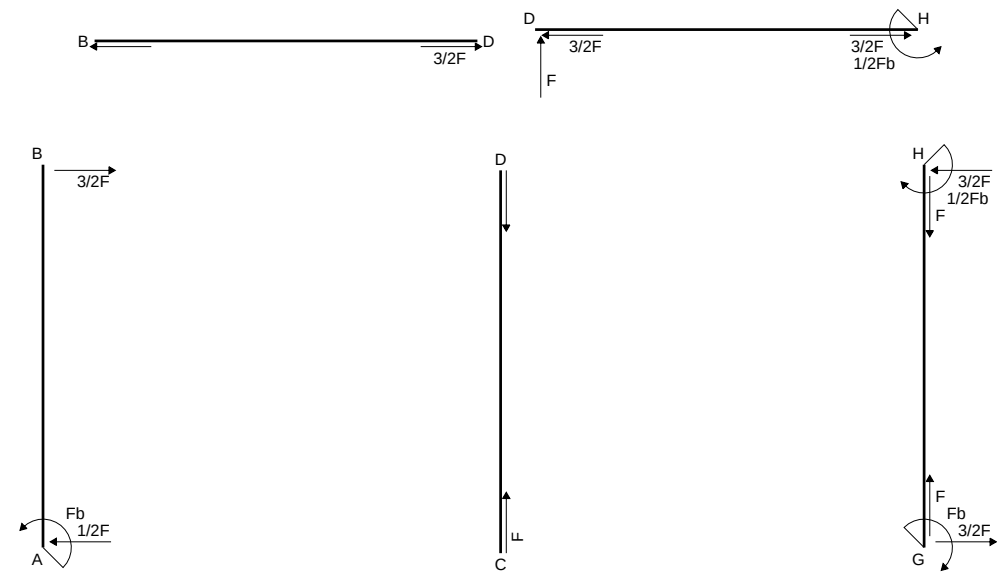
$$v_c = -19.73 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -159. \text{ N/mm}^2$$

$$\tau_c = 5.329 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 159.3 \text{ N/mm}^2$$

$$S = 4891. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-Fb+1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$3/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

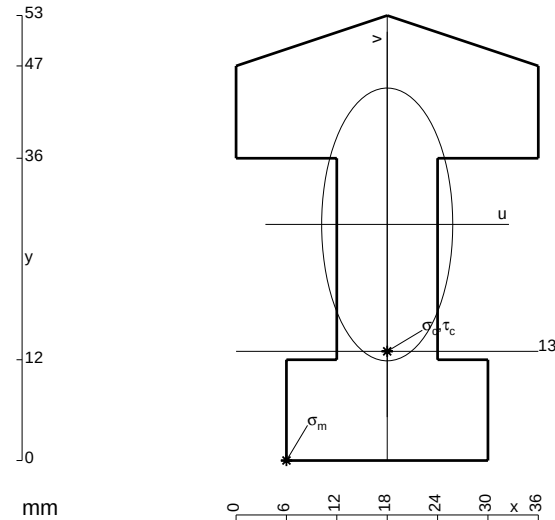
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1080. \text{ mm}^2$$

$$J_u = 285273. \text{ mm}^4$$

$$J_v = 65880. \text{ mm}^4$$

$$y_g = 28.12 \text{ mm}$$

$$T_y = 2560. \text{ N}$$

$$M_x = -2022400. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.12 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.3 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

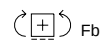
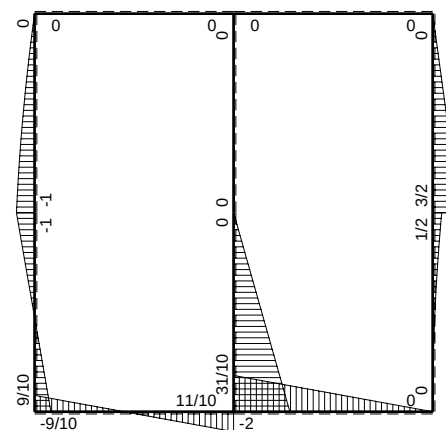
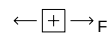
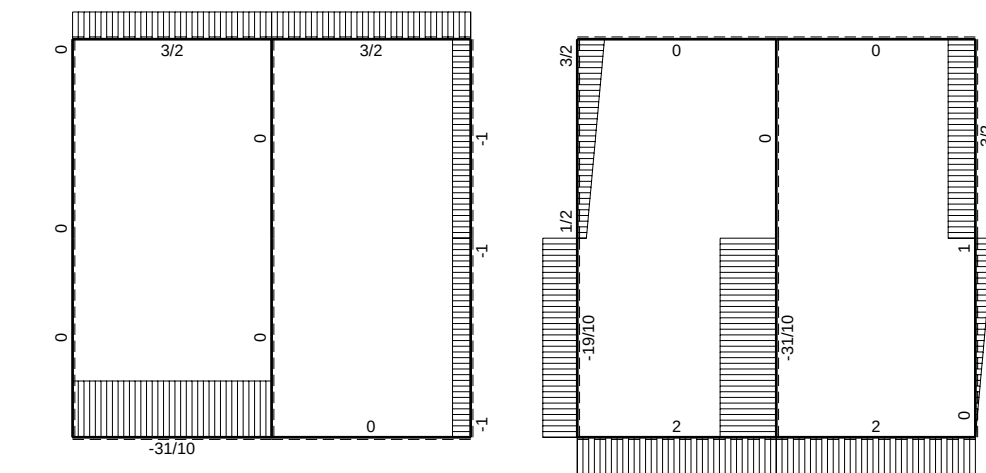
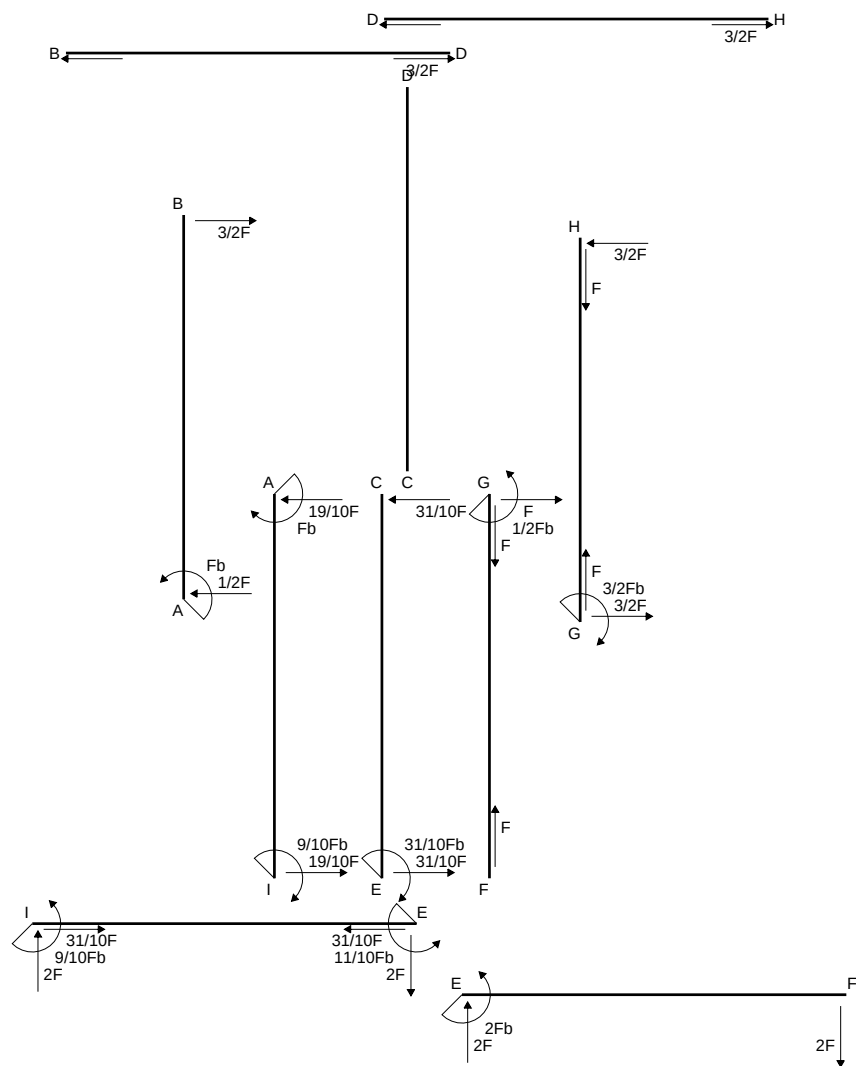
$$v_c = -15.12 \text{ mm}$$

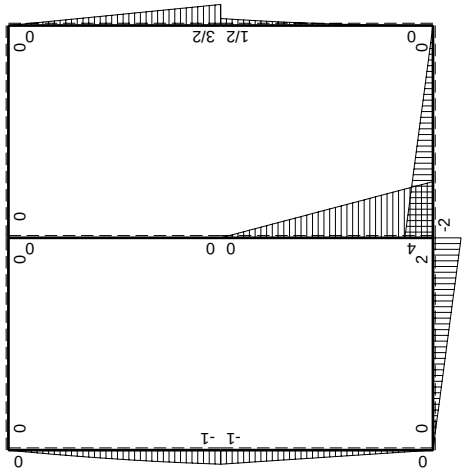
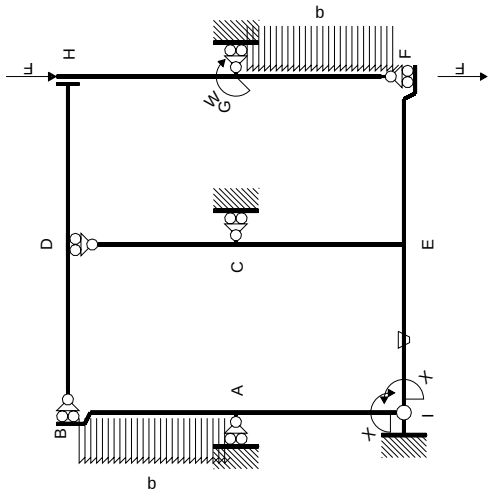
$$\sigma_c = -Mv/J_u = -107.2 \text{ N/mm}^2$$

$$\tau_c = 4.903 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 107.5 \text{ N/mm}^2$$

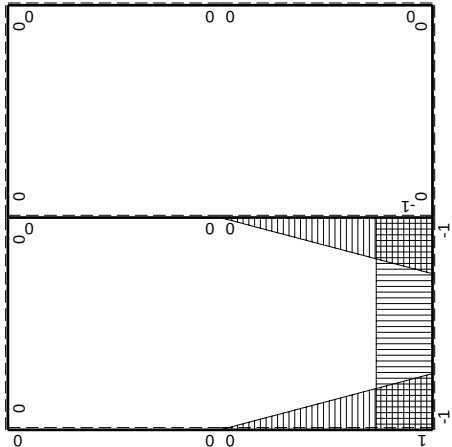
$$S = 6557. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-Fb+1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$3/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (-2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[-x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

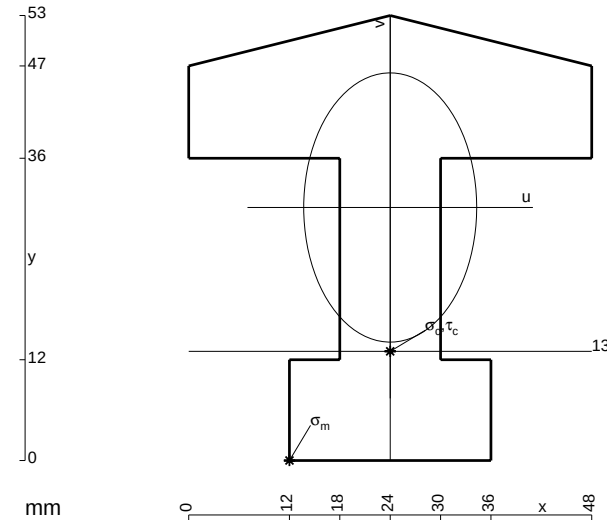
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1248. \text{ mm}^2$$

$$J_u = 320937. \text{ mm}^4$$

$$J_v = 132480. \text{ mm}^4$$

$$y_g = 30.13 \text{ mm}$$

$$T_y = 2660. \text{ N}$$

$$M_x = -2234400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.13 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

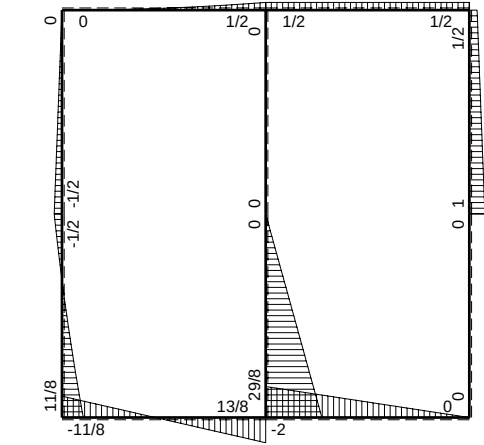
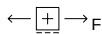
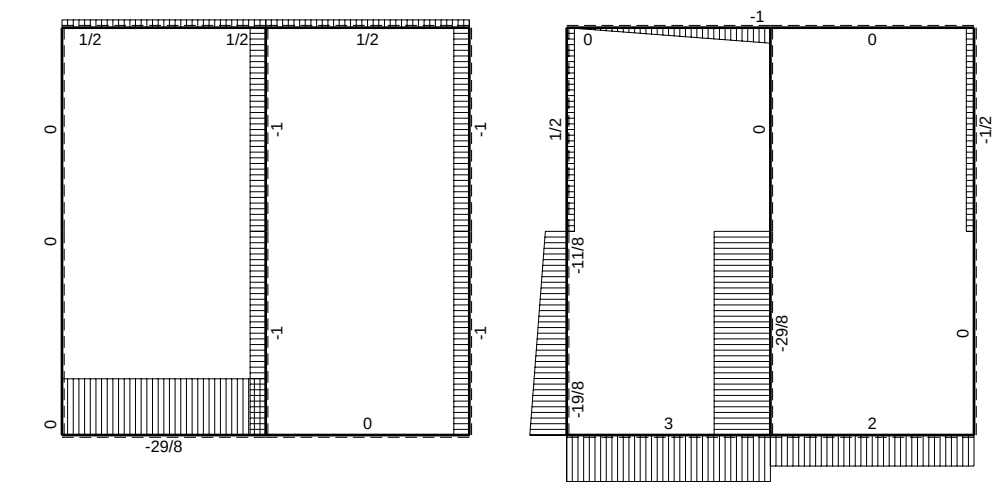
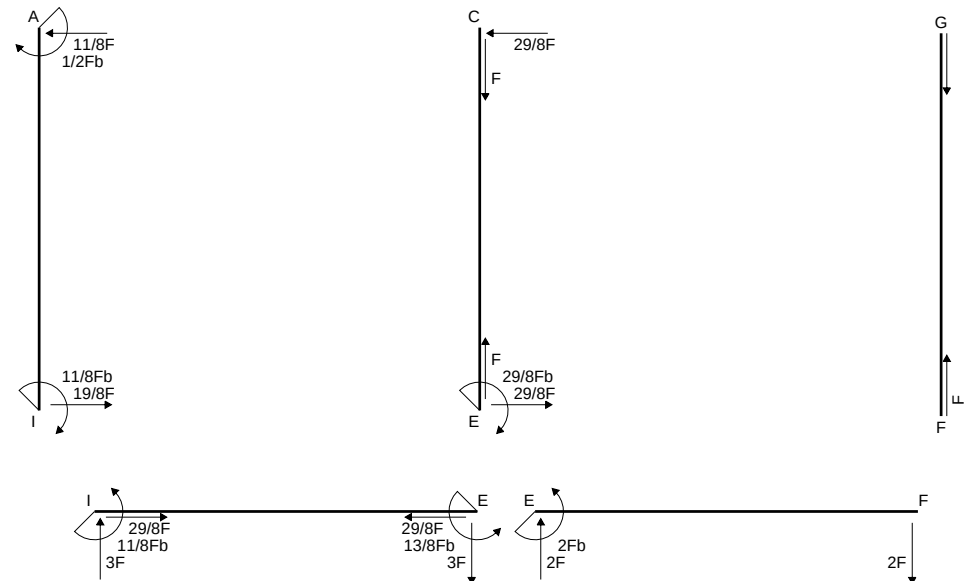
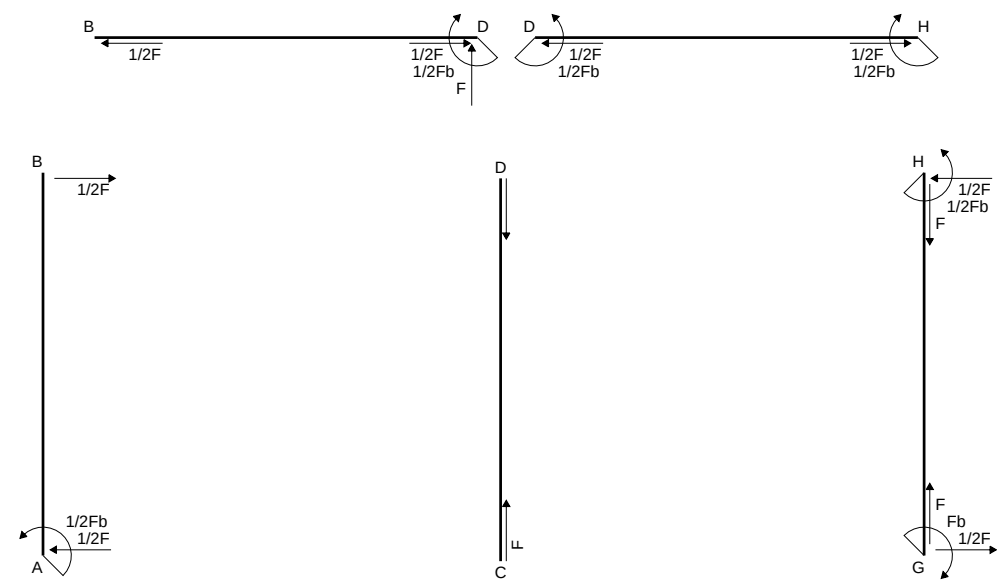
$$v_c = -17.13 \text{ mm}$$

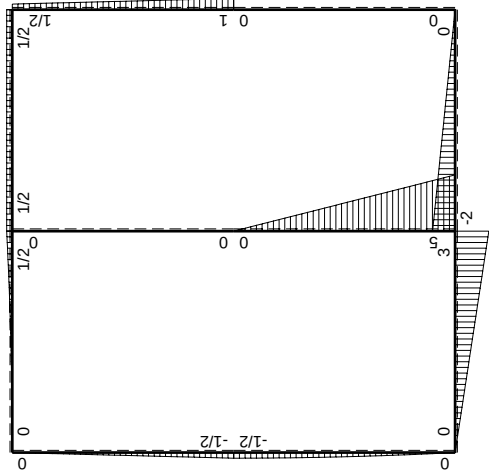
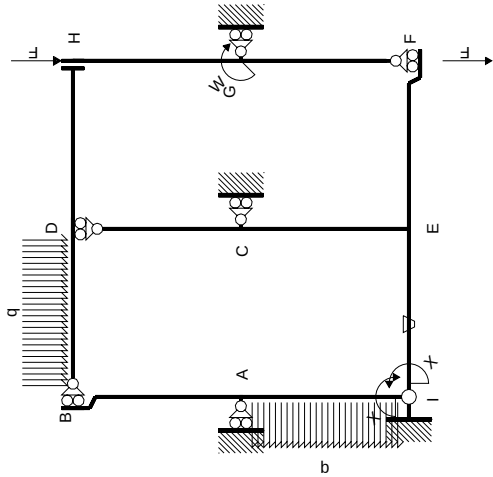
$$\sigma_c = -Mv/J_u = -119.3 \text{ N/mm}^2$$

$$\tau_c = 4.947 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 119.6 \text{ N/mm}^2$$

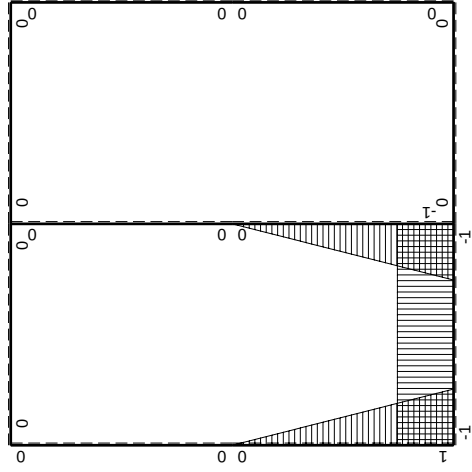
$$S = 7162. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

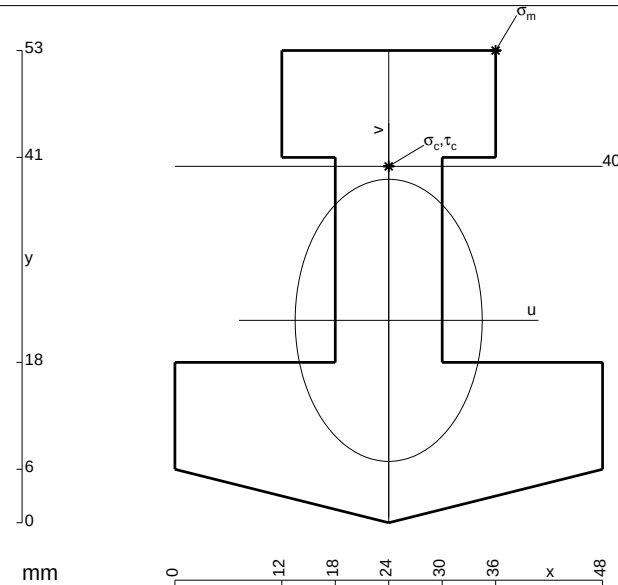
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 1284. \text{ mm}^2$$

$$J_u = 321948. \text{ mm}^4$$

$$J_v = 141552. \text{ mm}^4$$

$$y_g = 22.72 \text{ mm}$$

$$T_y = 2580. \text{ N}$$

$$M_x = -2322000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.28 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 218.4 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

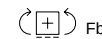
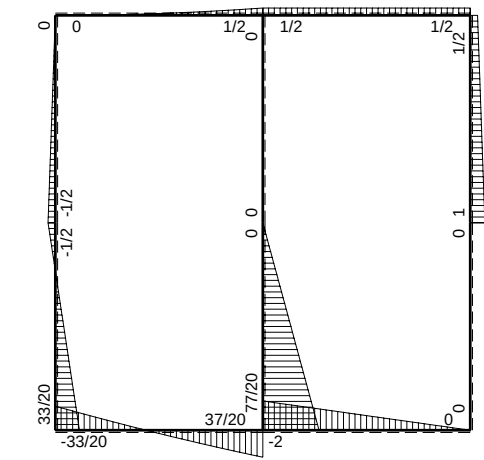
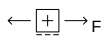
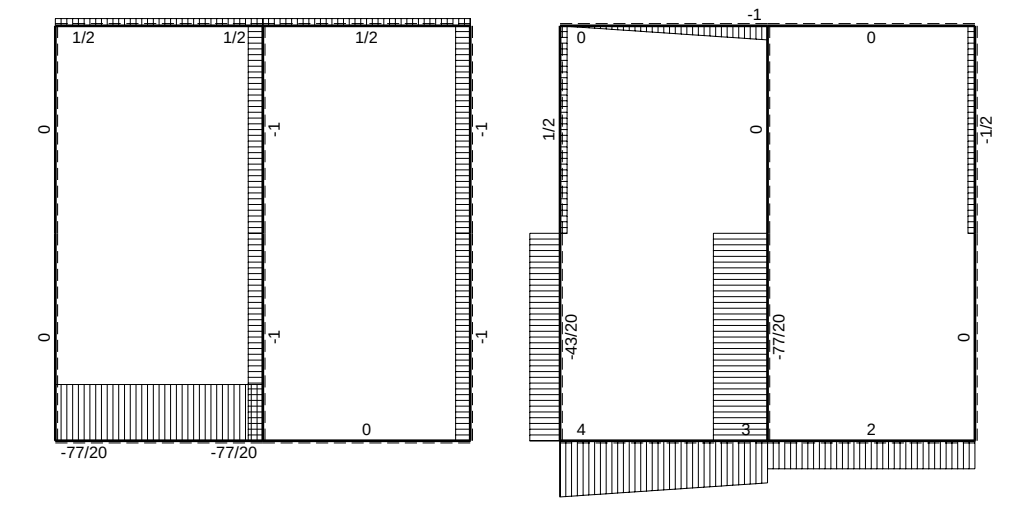
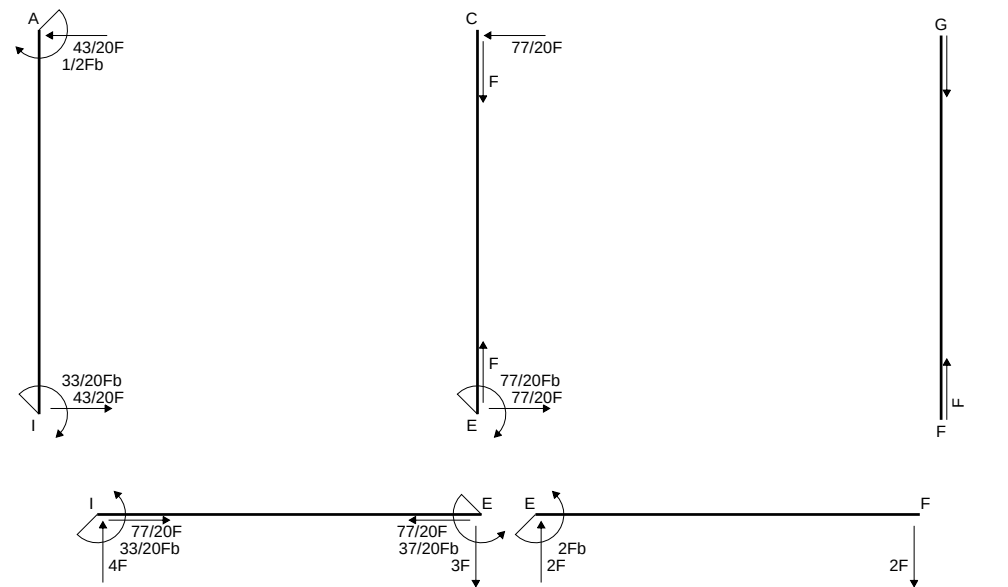
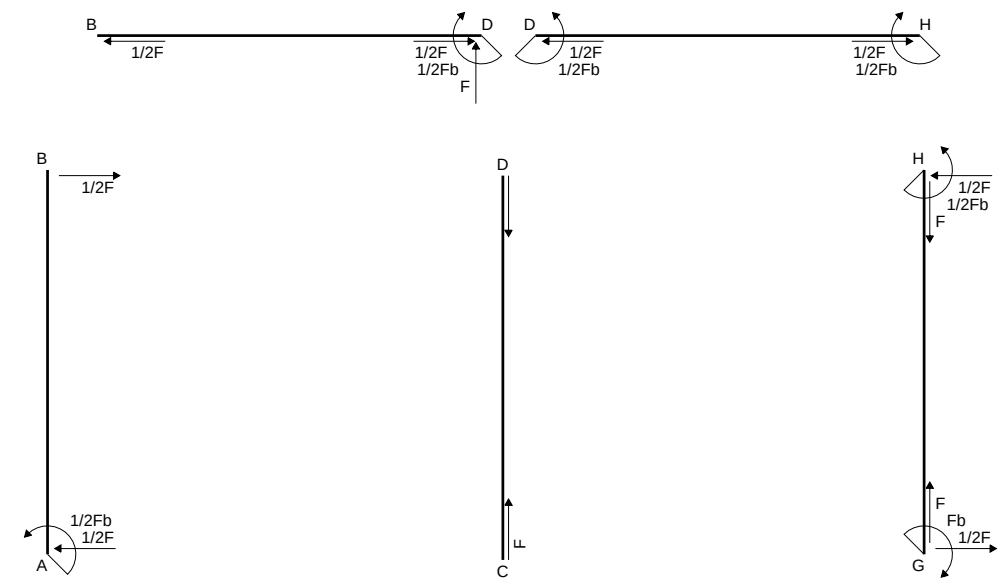
$$v_c = 17.28 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 124.7 \text{ N/mm}^2$$

$$\tau_c = 4.813 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 124.9 \text{ N/mm}^2$$

$$S = 7208. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

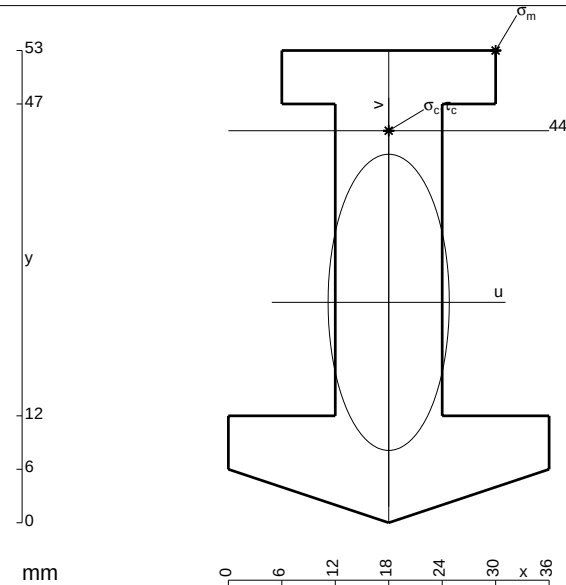
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 888. \text{ mm}^2$$

$$J_u = 245538. \text{ mm}^4$$

$$J_v = 41112. \text{ mm}^4$$

$$y_g = 24.74 \text{ mm}$$

$$T_y = 2100. \text{ N}$$

$$M_x = -1995000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.26 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

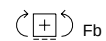
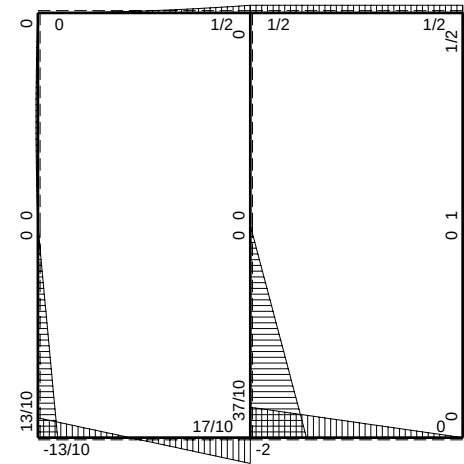
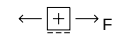
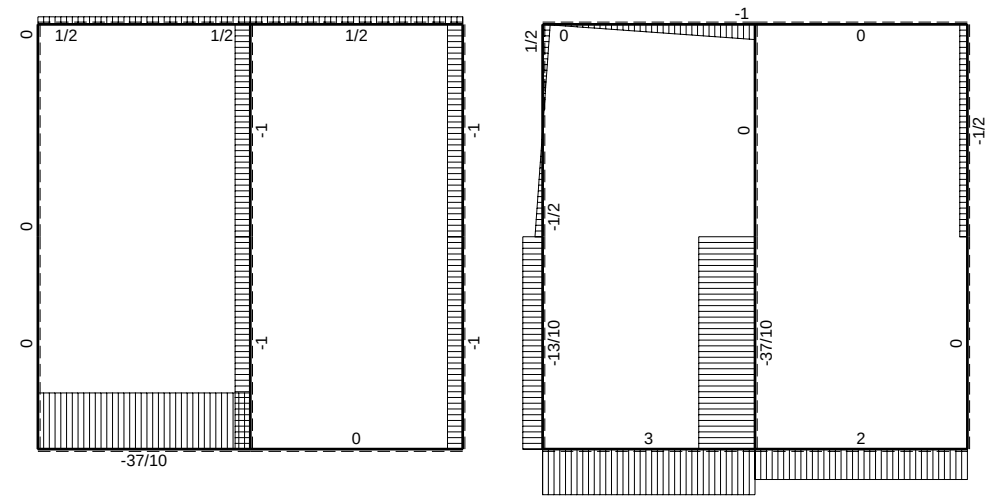
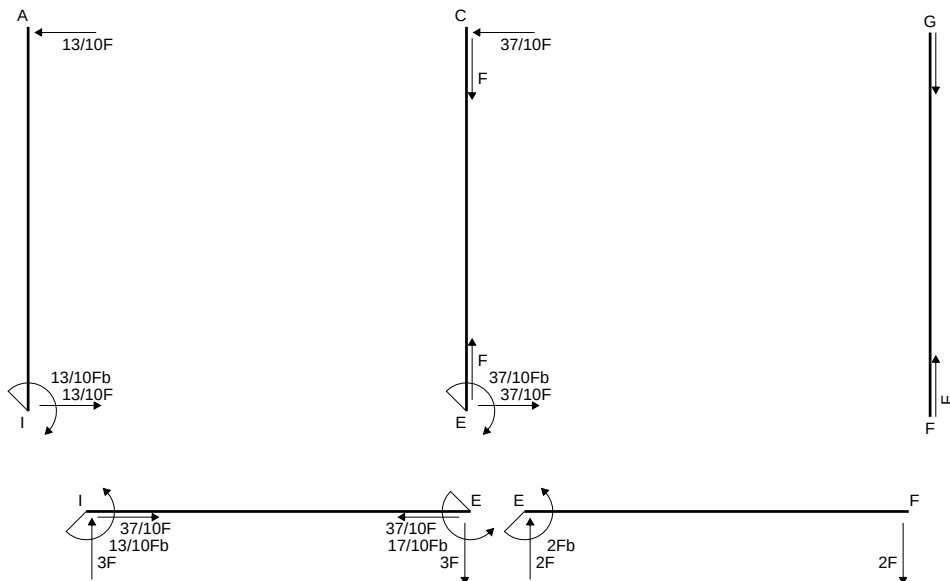
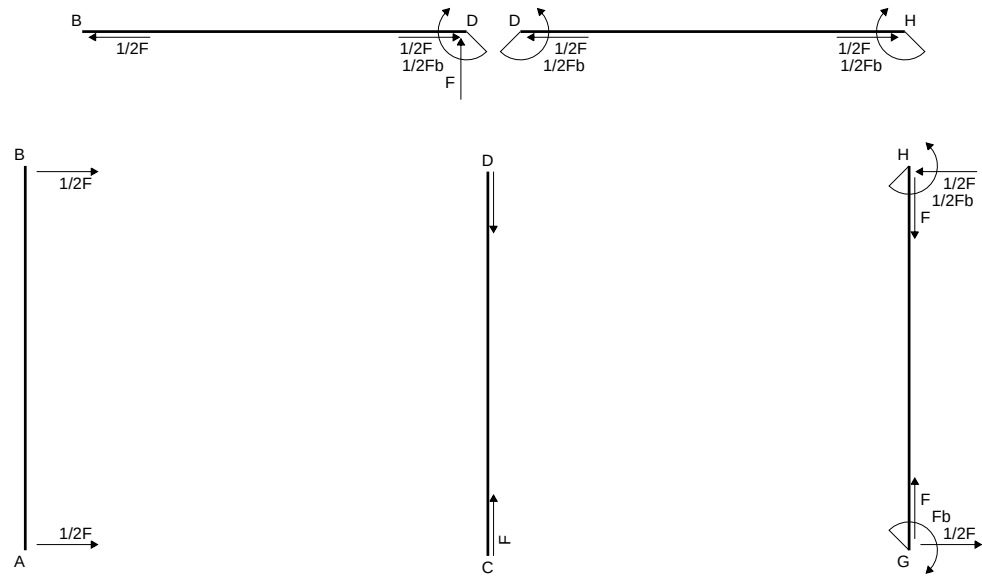
$$v_c = 19.26 \text{ mm}$$

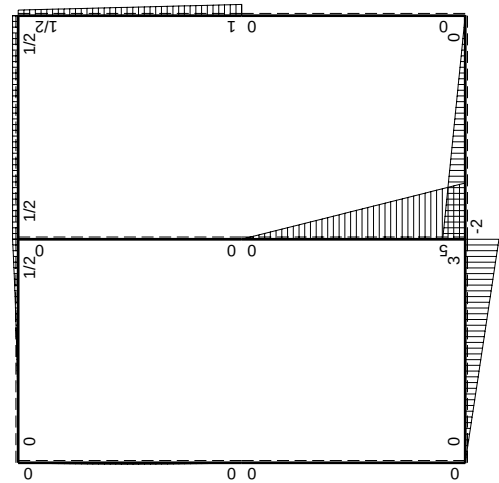
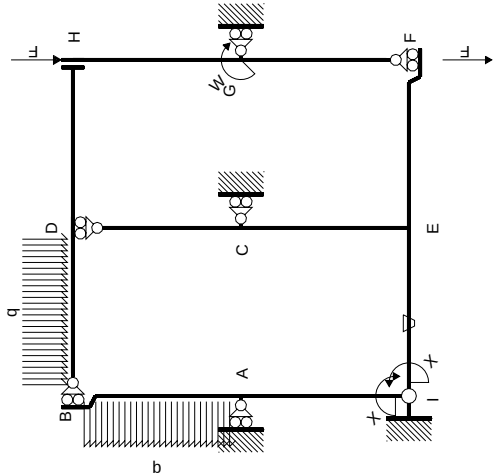
$$\sigma_c = -Mv/J_u = 156.5 \text{ N/mm}^2$$

$$\tau_c = 3.126 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 156.6 \text{ N/mm}^2$$

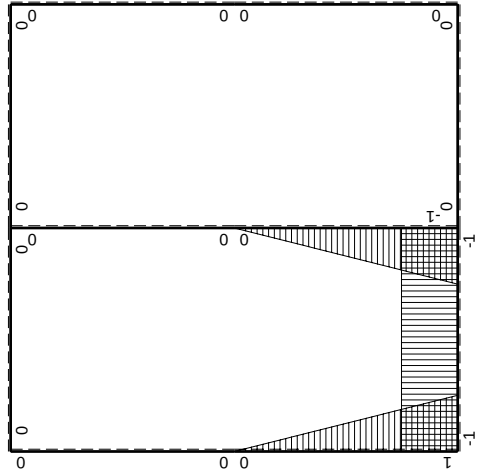
$$S = 4385. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati

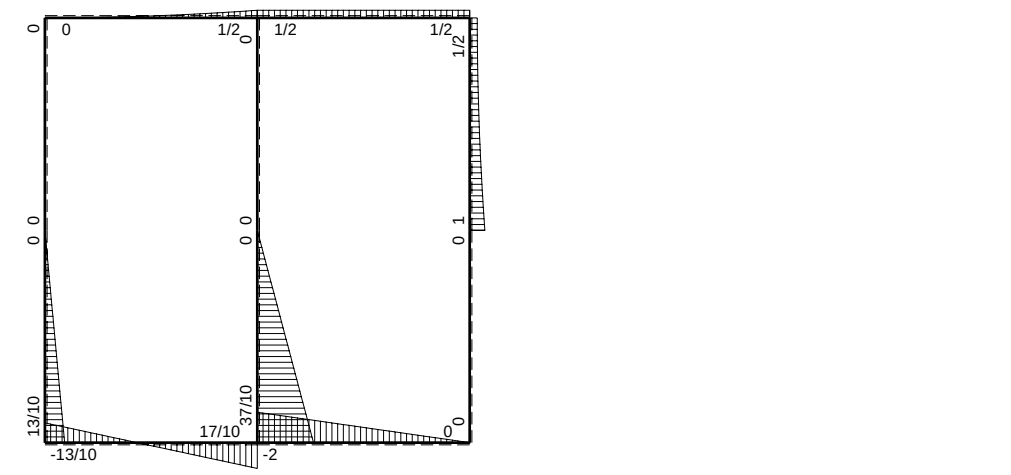
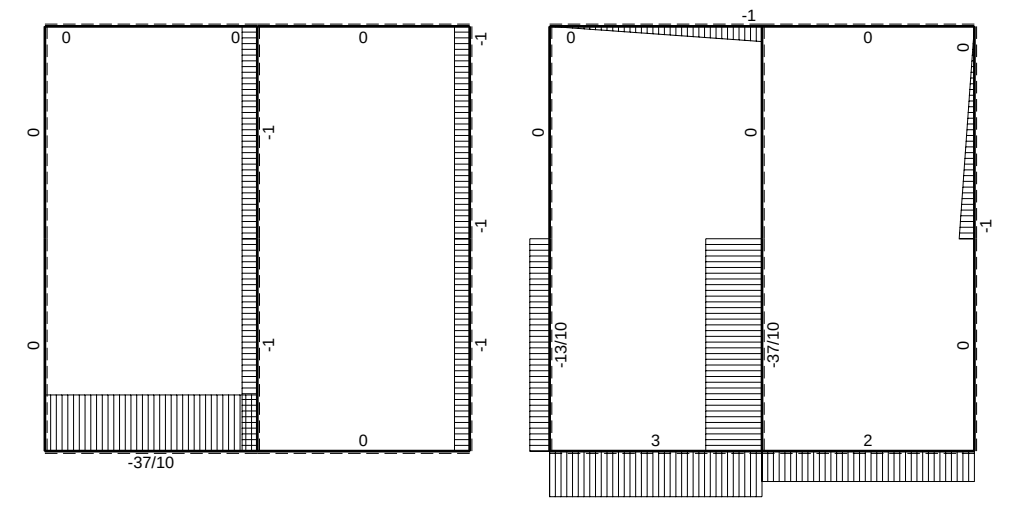
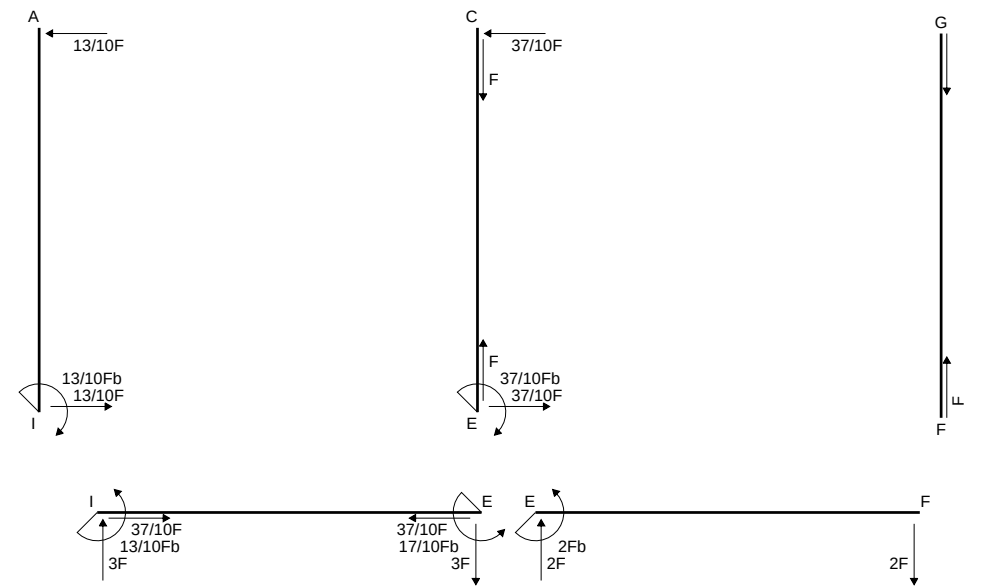
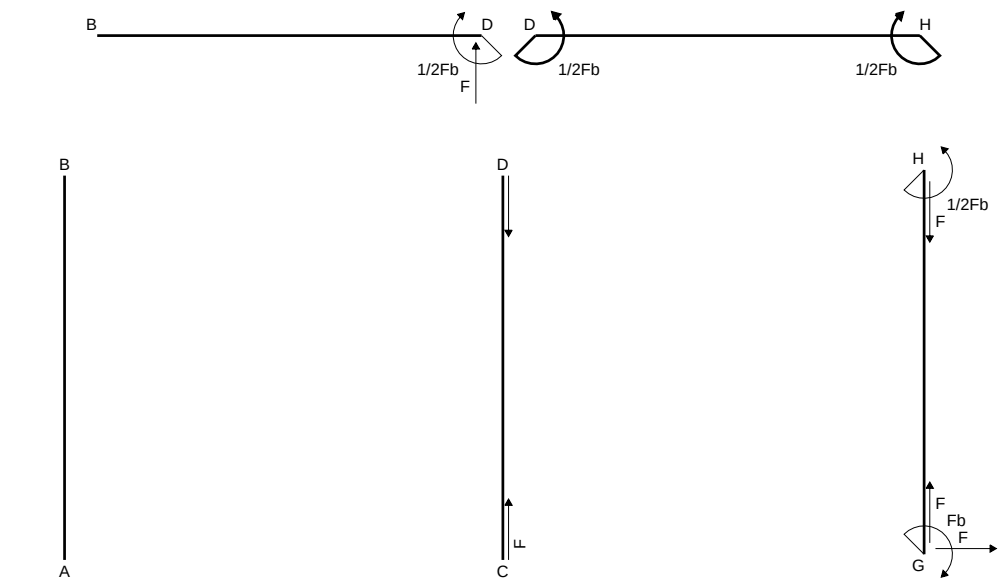


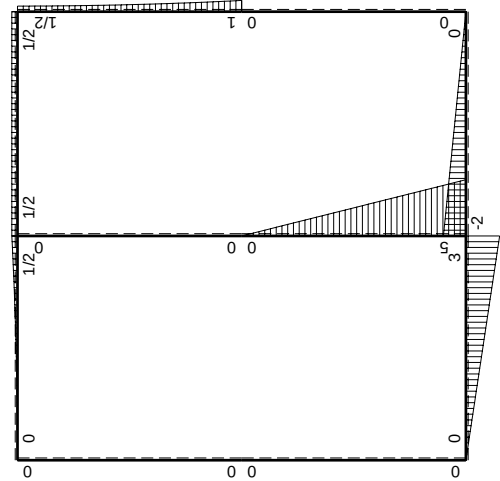
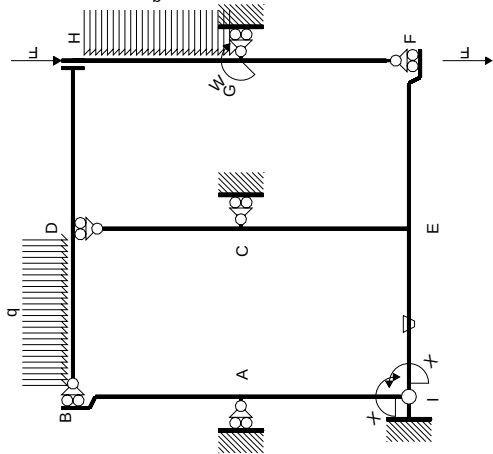
M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

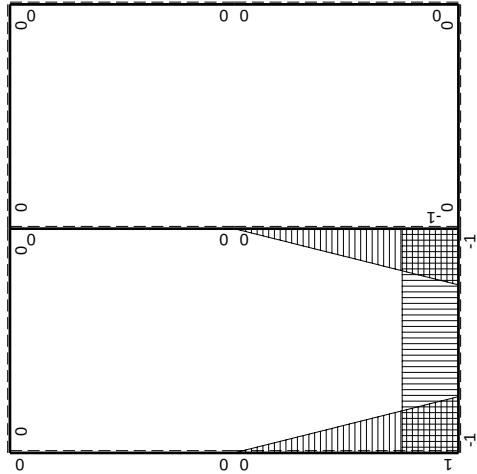
Sviluppi di calcolo iperstatica





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

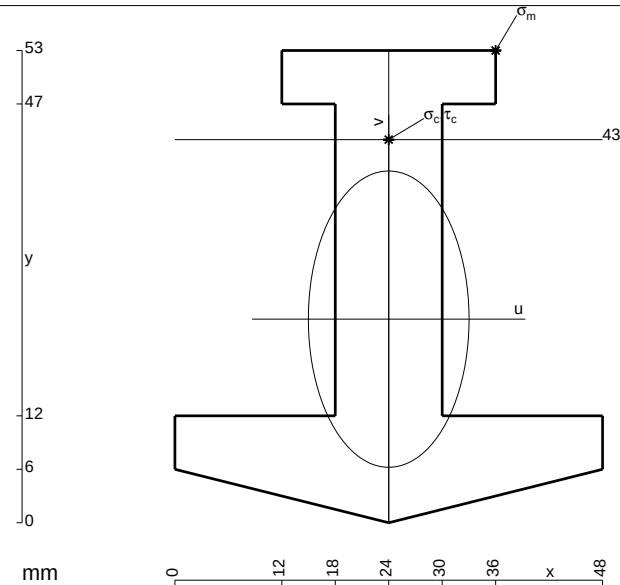
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

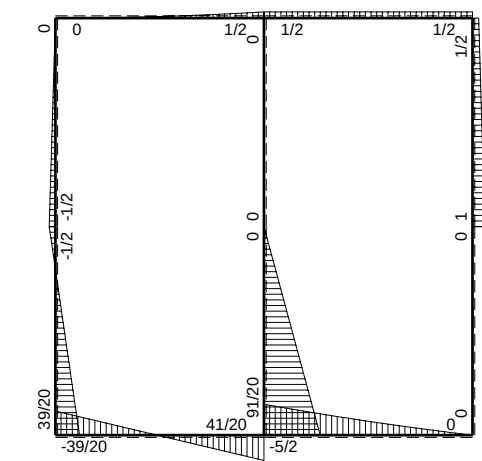
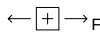
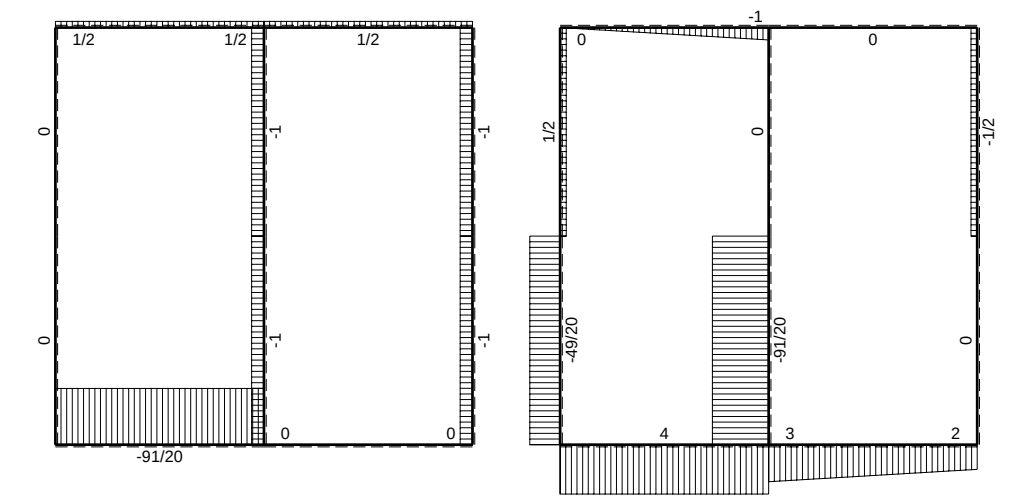
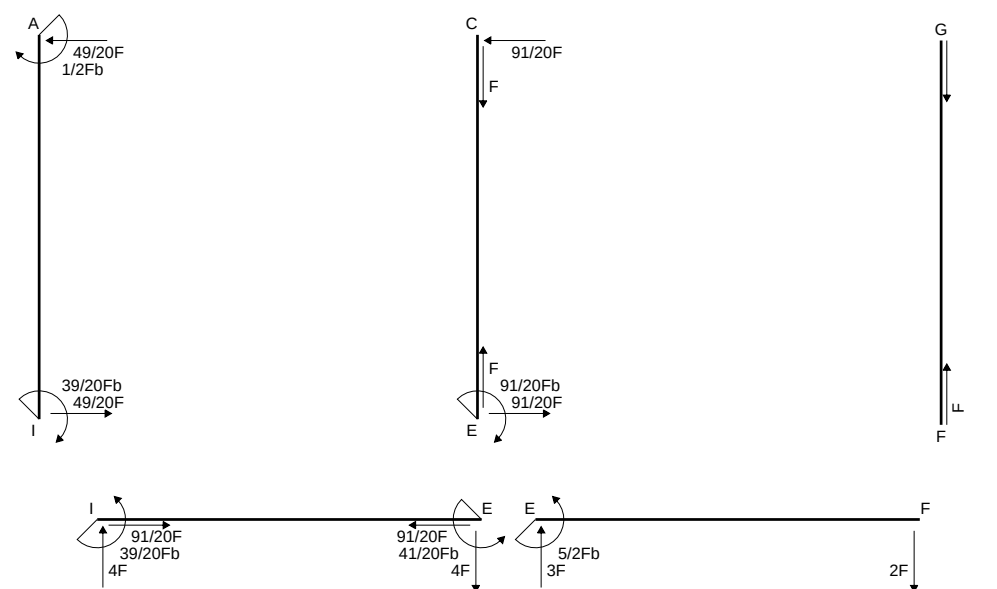
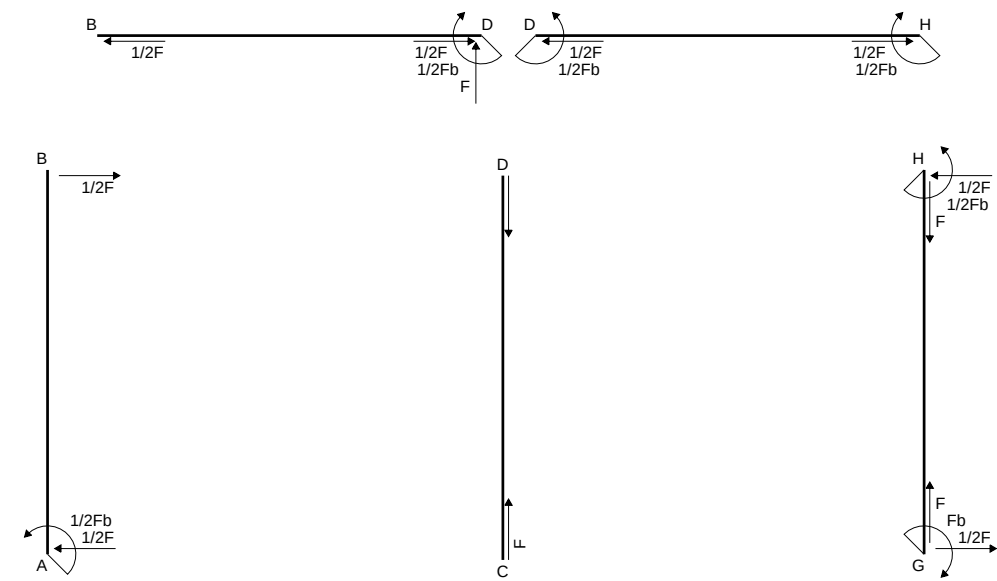
$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$



$$\begin{aligned} A &= 996. \text{ mm}^2 \\ J_u &= 275589. \text{ mm}^4 \\ J_v &= 81072. \text{ mm}^4 \\ y_g &= 22.85 \text{ mm} \\ T_y &= 3440. \text{ N} \\ M_x &= -1823200. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.15 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 20.15 \text{ mm} \\ \sigma_c &= -Mv/J_u = 133.3 \text{ N/mm}^2 \\ \tau_c &= 5.173 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 133.6 \text{ N/mm}^2 \\ S &= 4973. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-13/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$39/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

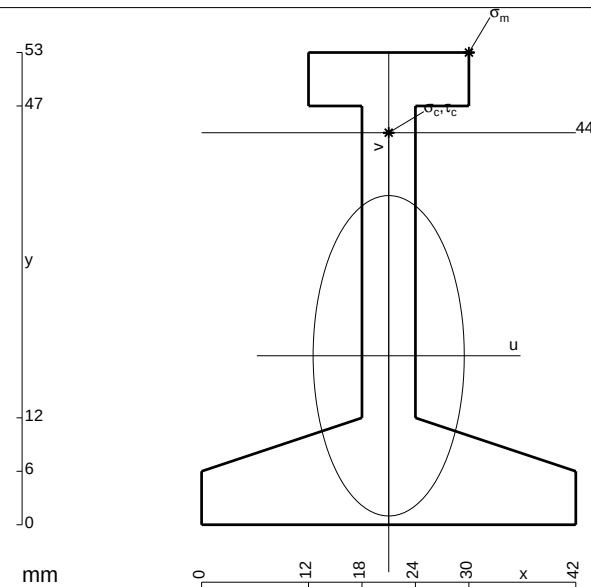
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 714. \text{ mm}^2$$

$$J_u = 230961. \text{ mm}^4$$

$$J_v = 51390. \text{ mm}^4$$

$$y_g = 18.96 \text{ mm}$$

$$T_y = 2940. \text{ N}$$

$$M_x = -1421000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 34.04 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

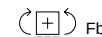
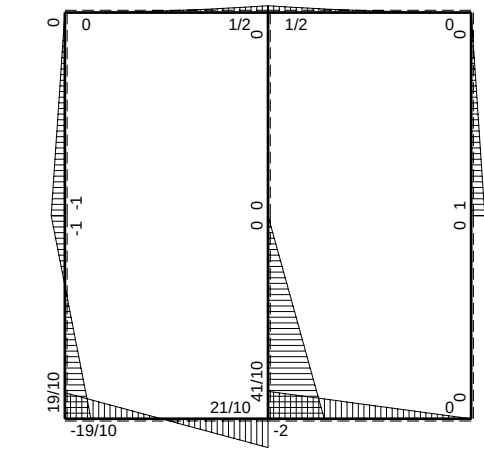
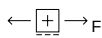
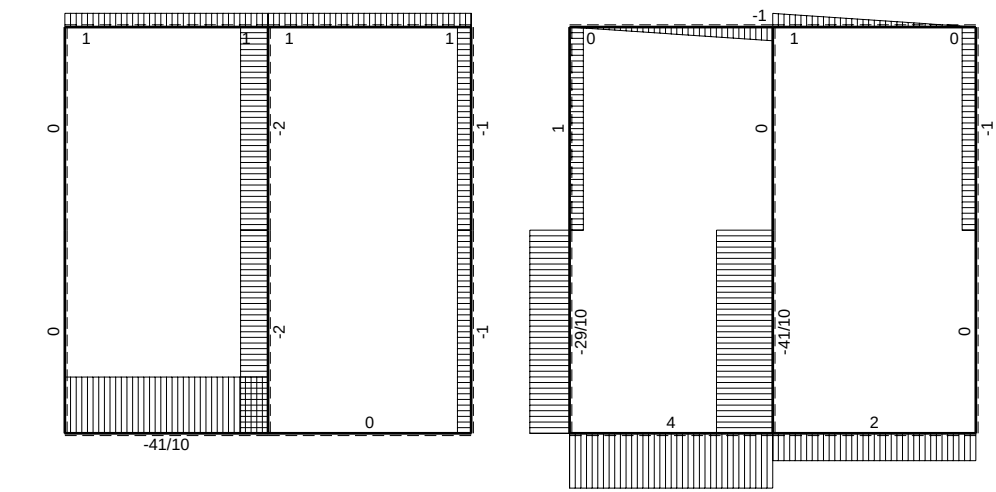
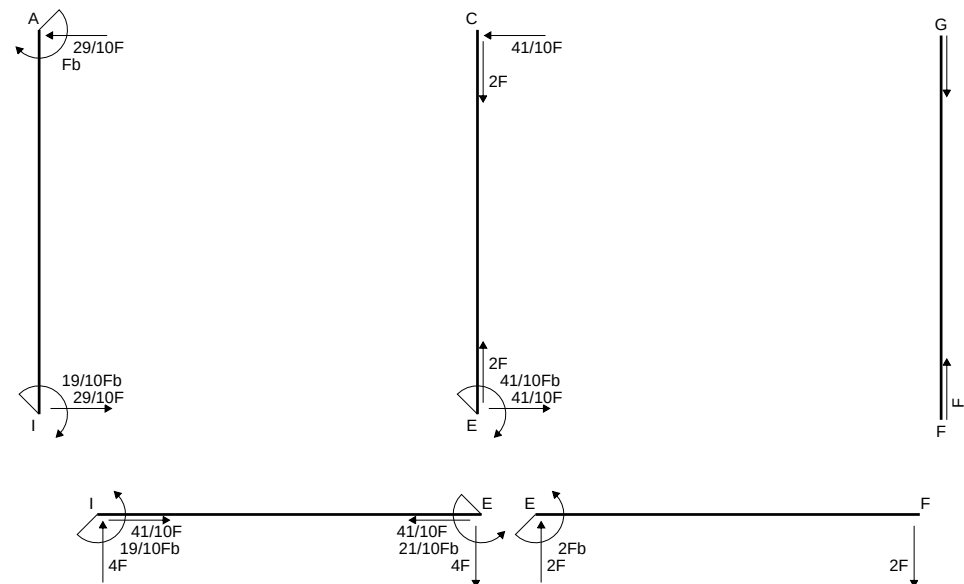
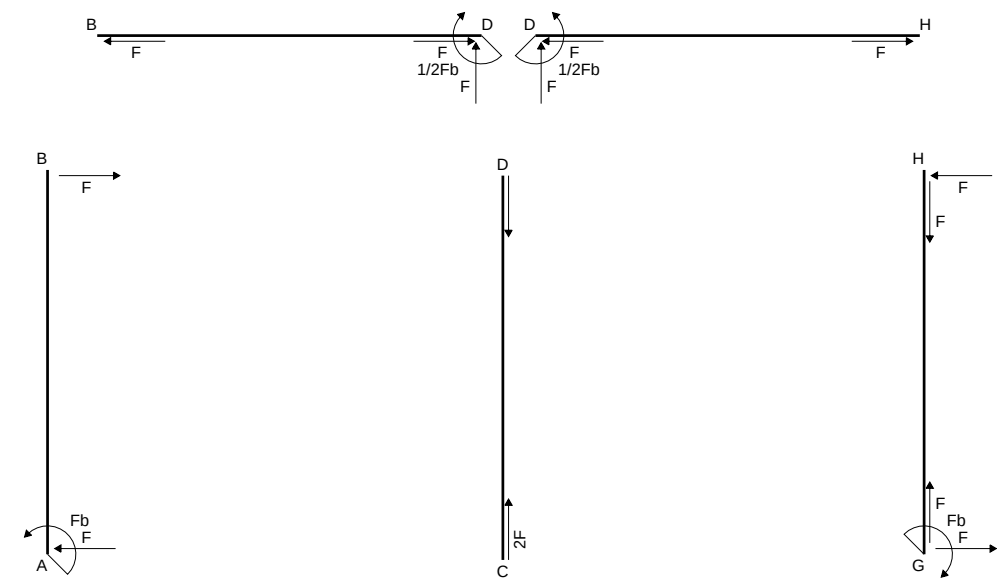
$$v_c = 25.04 \text{ mm}$$

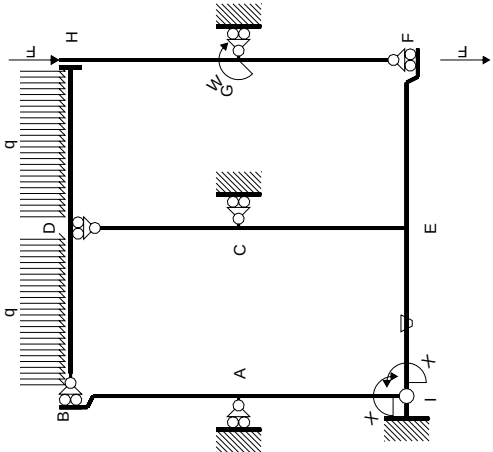
$$\sigma_c = -Mv/J_u = 154. \text{ N/mm}^2$$

$$\tau_c = 8.125 \text{ N/mm}^2$$

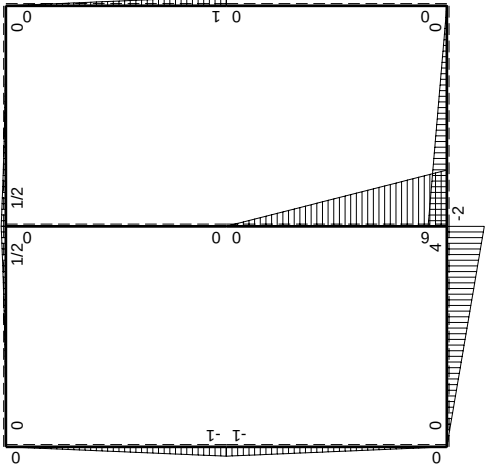
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 154.7 \text{ N/mm}^2$$

$$S = 3830. \text{ mm}^3$$

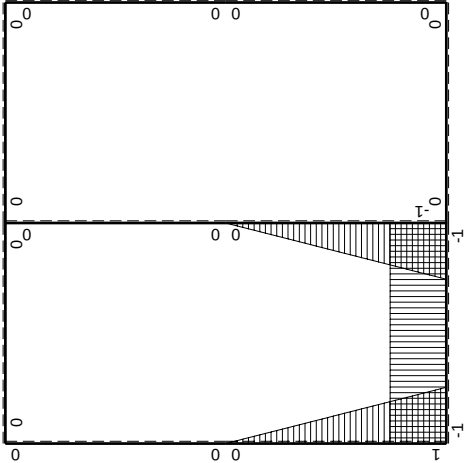




Schema di calcolo iperstatico



M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	4Fx	-Fb/EJ	-4Fx	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-4Fb+4Fx	Fb/EJ	-4Fb+4Fx	Fb/EJ	1		
EC b	$-1+x/b$	6Fb-6Fx	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-6Fx	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-19/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

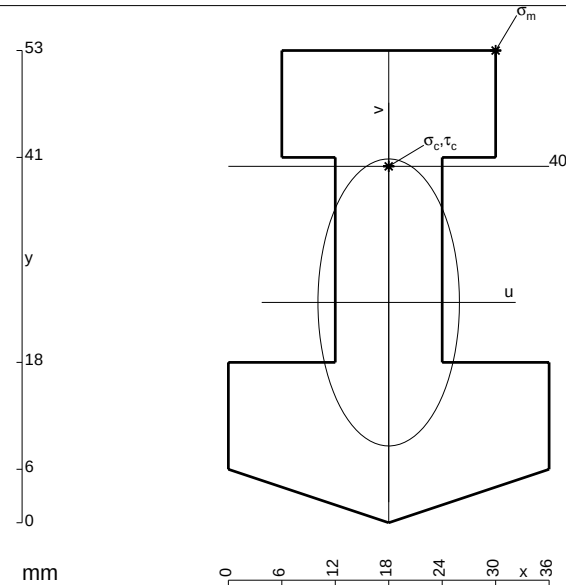
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1104. \text{ mm}^2$$

$$J_u = 286555. \text{ mm}^4$$

$$J_v = 69624. \text{ mm}^4$$

$$y_g = 24.72 \text{ mm}$$

$$T_y = 3520. \text{ N}$$

$$M_x = -2217600. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.28 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 218.8 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

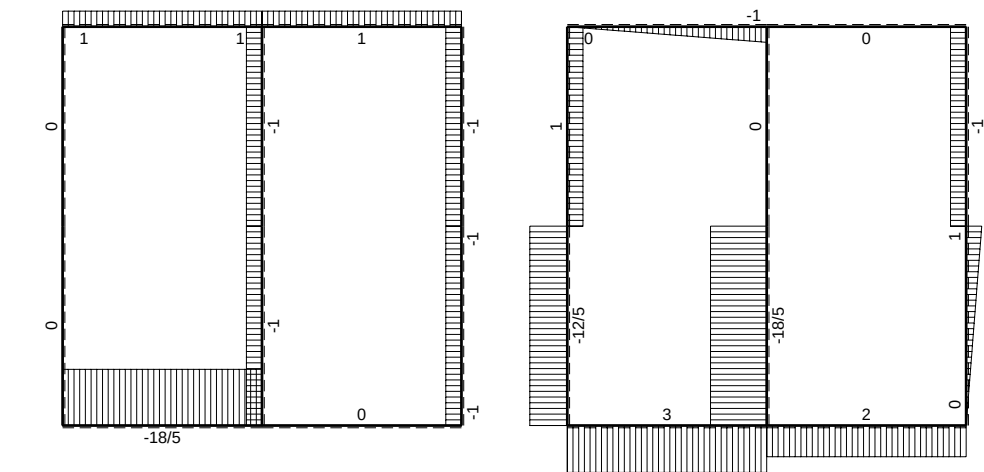
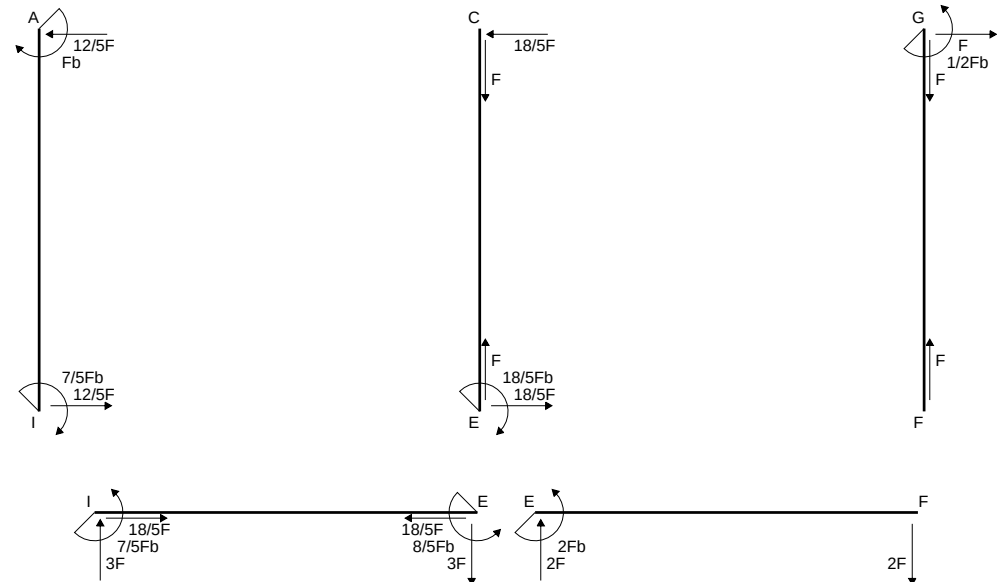
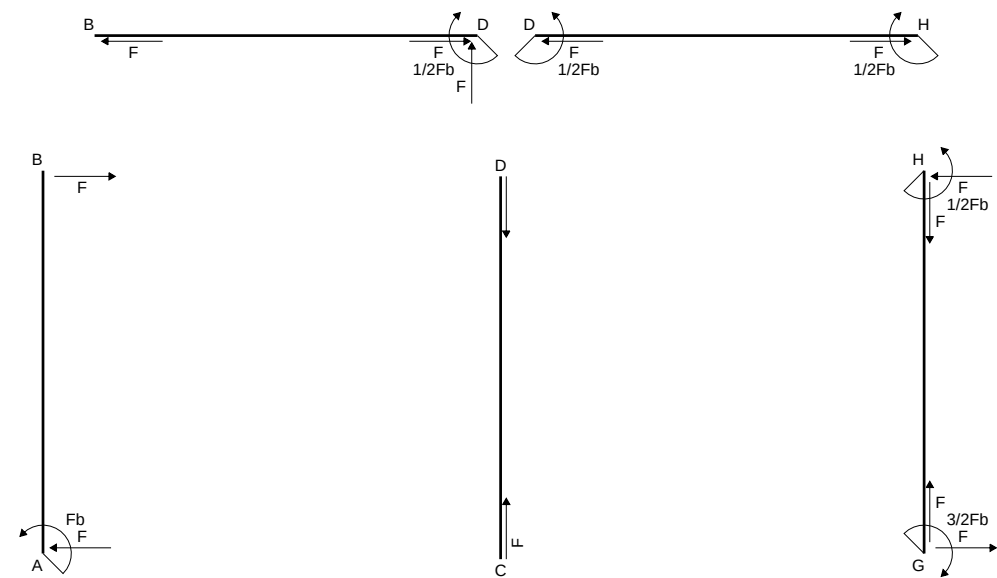
$$v_c = 15.28 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 118.2 \text{ N/mm}^2$$

$$\tau_c = 6.761 \text{ N/mm}^2$$

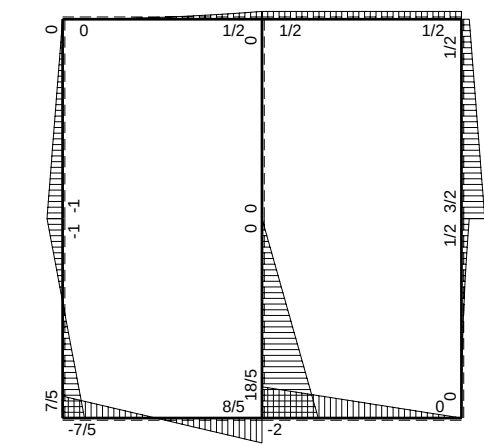
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 118.8 \text{ N/mm}^2$$

$$S = 6605. \text{ mm}^3$$



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↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

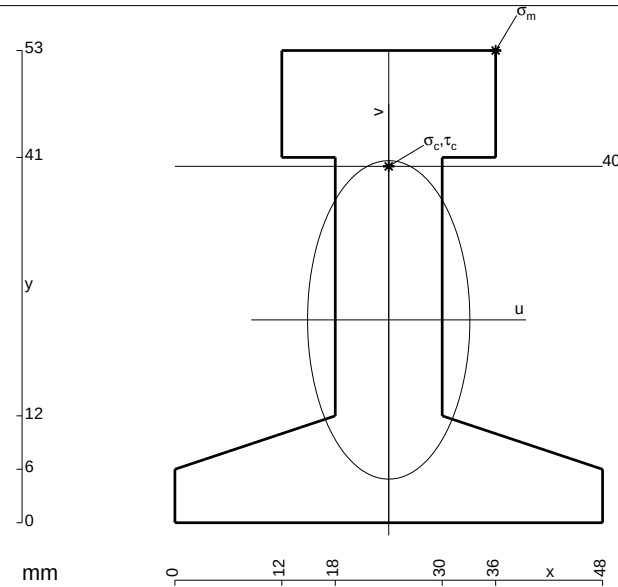
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1104. \text{ mm}^2$$

$$J_u = 352844. \text{ mm}^4$$

$$J_v = 91656. \text{ mm}^4$$

$$y_g = 22.77 \text{ mm}$$

$$T_y = 3940. \text{ N}$$

$$M_x = -2679200. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.23 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

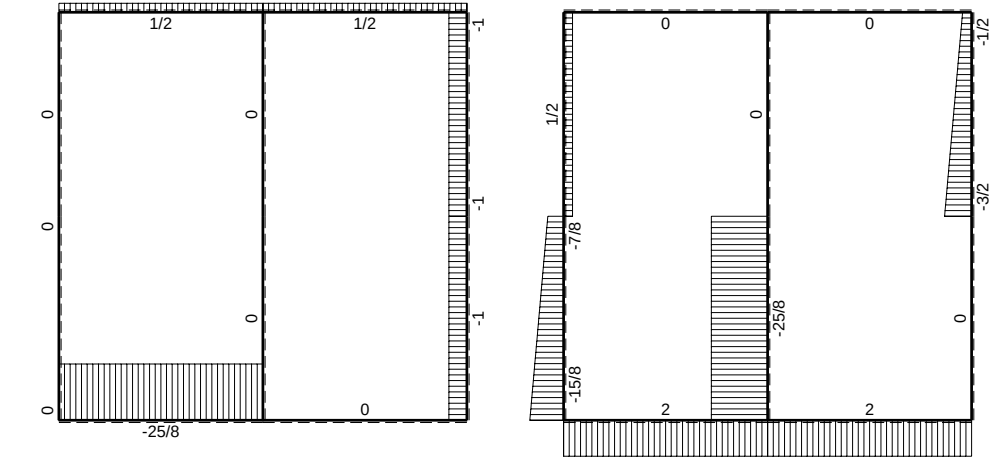
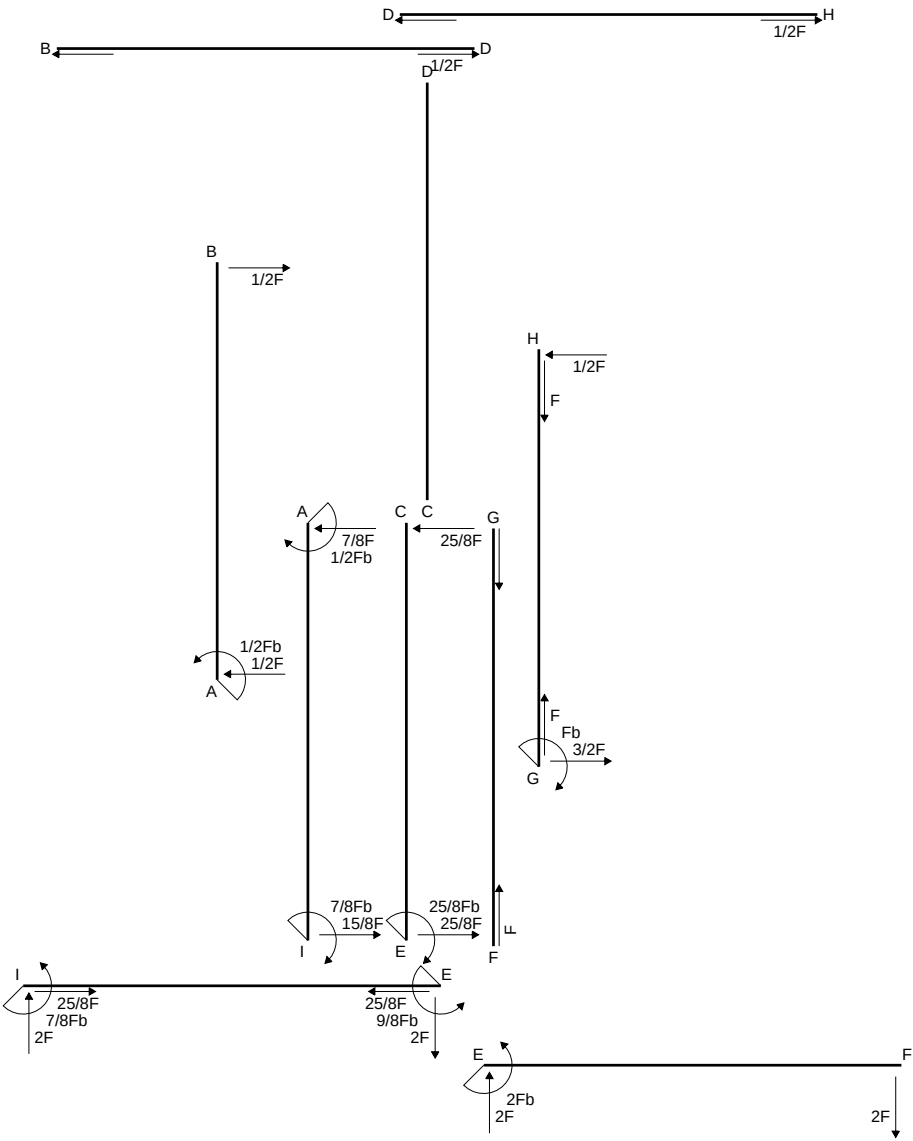
$$v_c = 17.23 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 130.9 \text{ N/mm}^2$$

$$\tau_c = 6.693 \text{ N/mm}^2$$

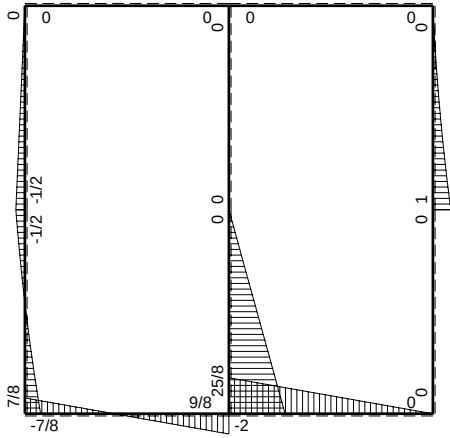
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 131.4 \text{ N/mm}^2$$

$$S = 7192. \text{ mm}^3$$

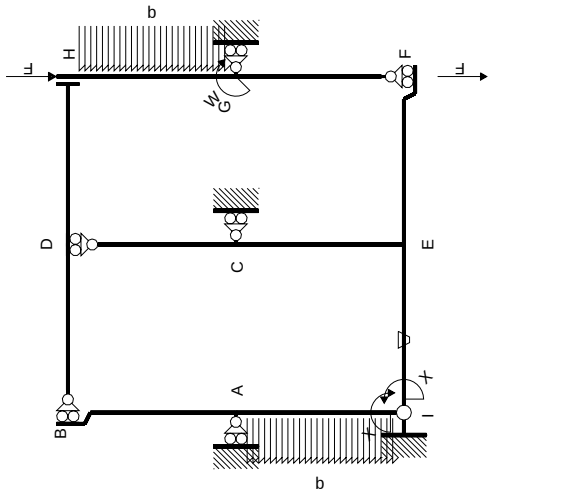


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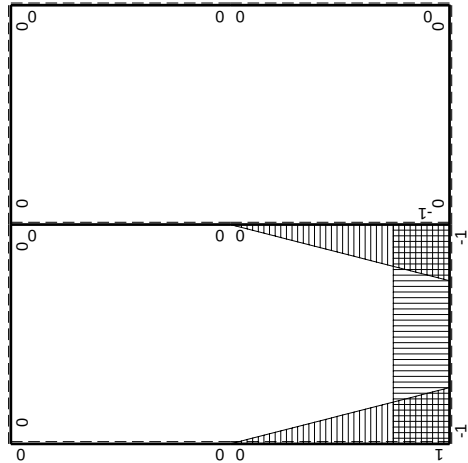


⊕ ⊖ Fb



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fb+1/2qx^3/b$	0	x^2/b^2		
	totali						$-35/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

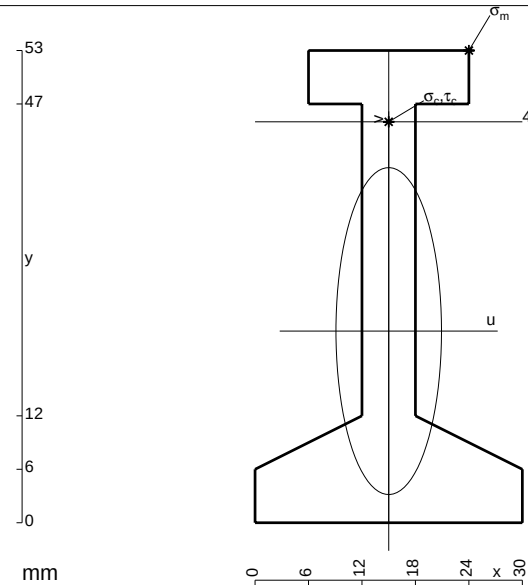
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 606. \text{ mm}^2$$

$$J_u = 204068. \text{ mm}^4$$

$$J_v = 21258. \text{ mm}^4$$

$$y_g = 21.51 \text{ mm}$$

$$T_y = 2100. \text{ N}$$

$$M_x = -1554000. \text{ Nmm}$$

$$x_m = 24. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 31.49 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239.8 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 45. \text{ mm}$$

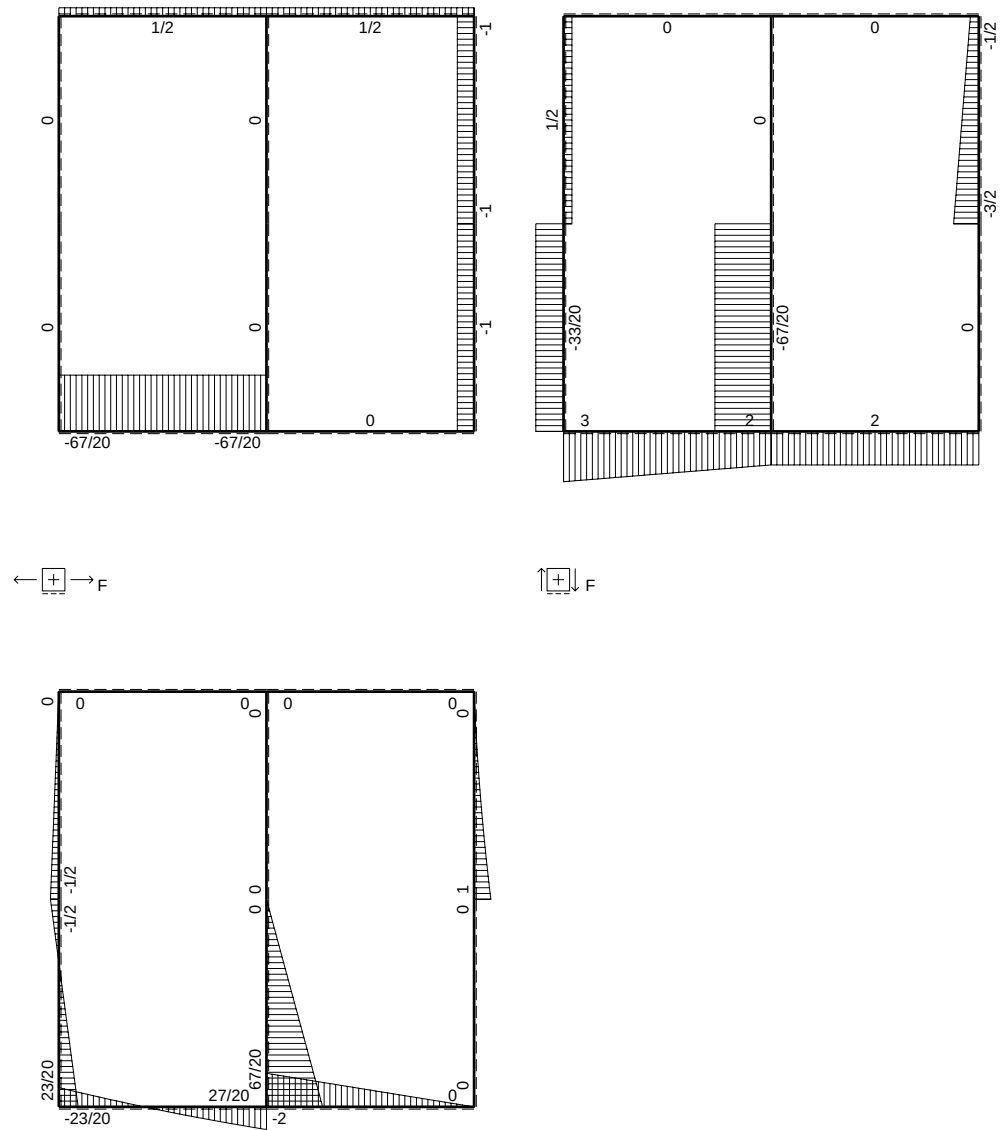
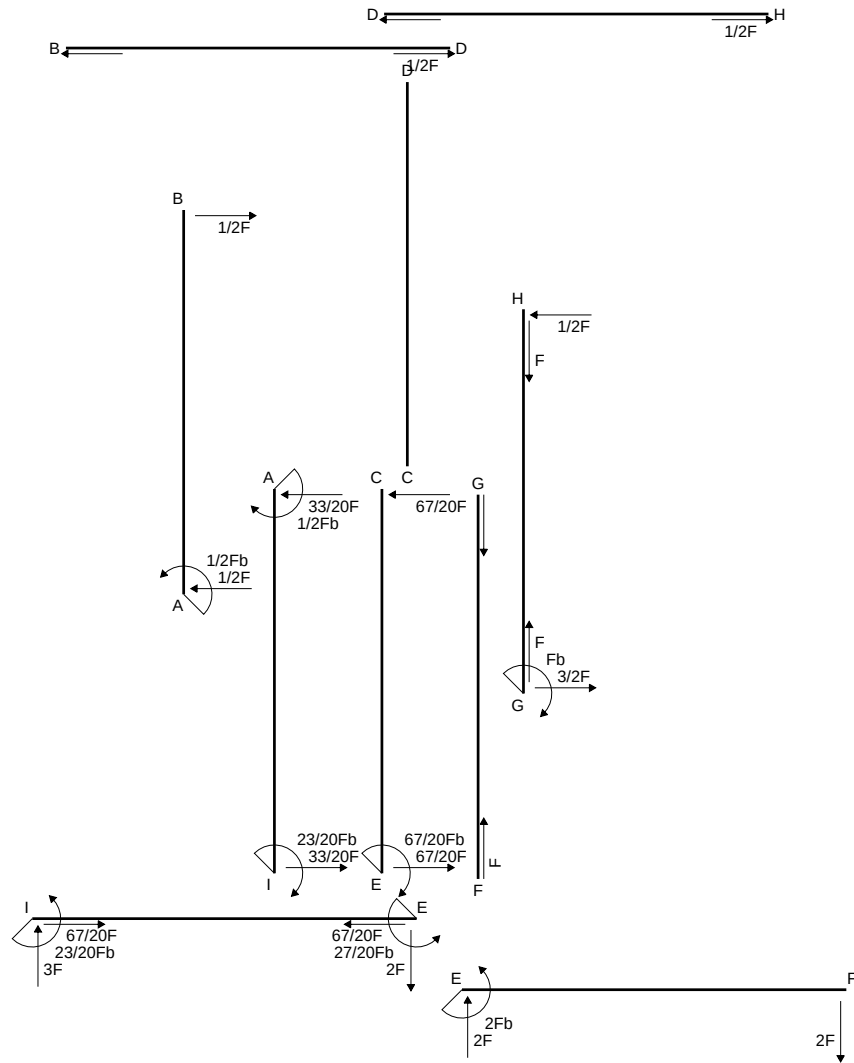
$$v_c = 23.49 \text{ mm}$$

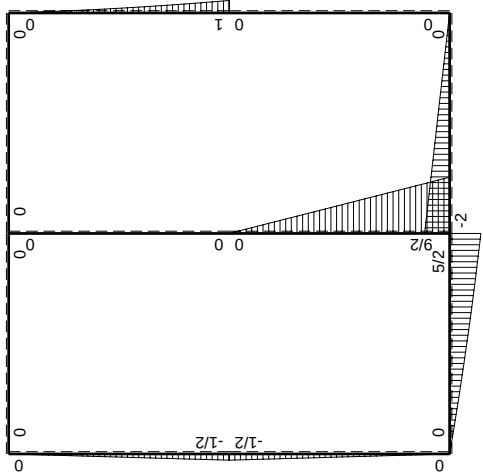
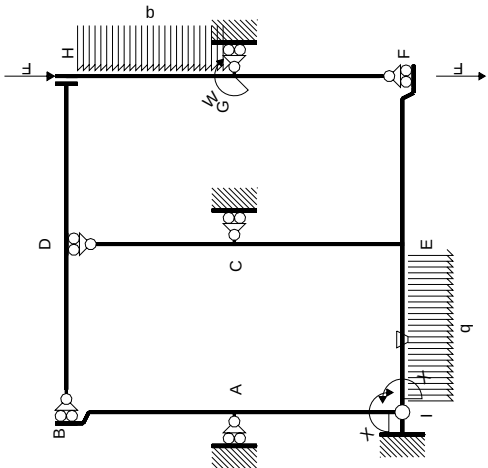
$$\sigma_c = -Mv/J_u = 178.9 \text{ N/mm}^2$$

$$\tau_c = 5.781 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 179.2 \text{ N/mm}^2$$

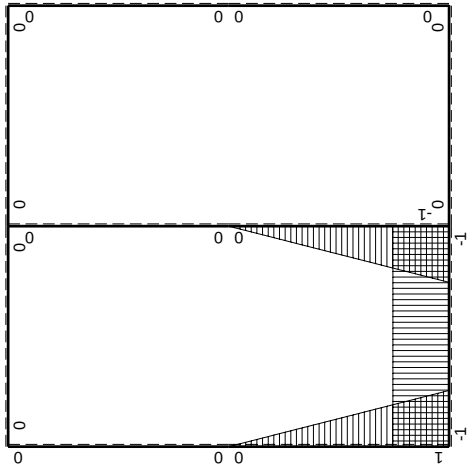
$$S = 3371. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-23/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$23/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

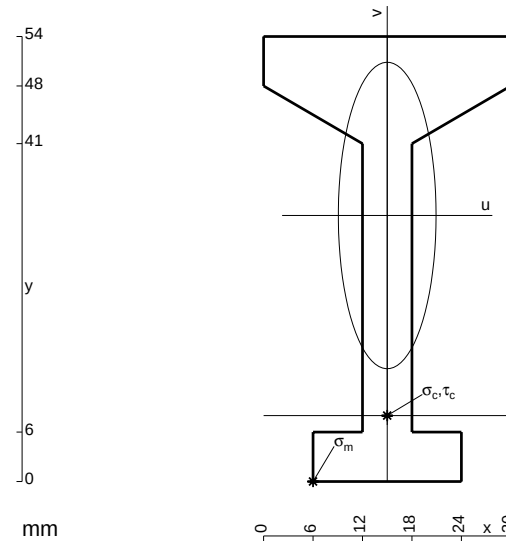
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 624. \text{ mm}^2$$

$$J_u = 215884. \text{ mm}^4$$

$$J_v = 21960. \text{ mm}^4$$

$$y_g = 32.28 \text{ mm}$$

$$T_y = 1640. \text{ N}$$

$$M_x = -1328400. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -32.28 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -198.6 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 8. \text{ mm}$$

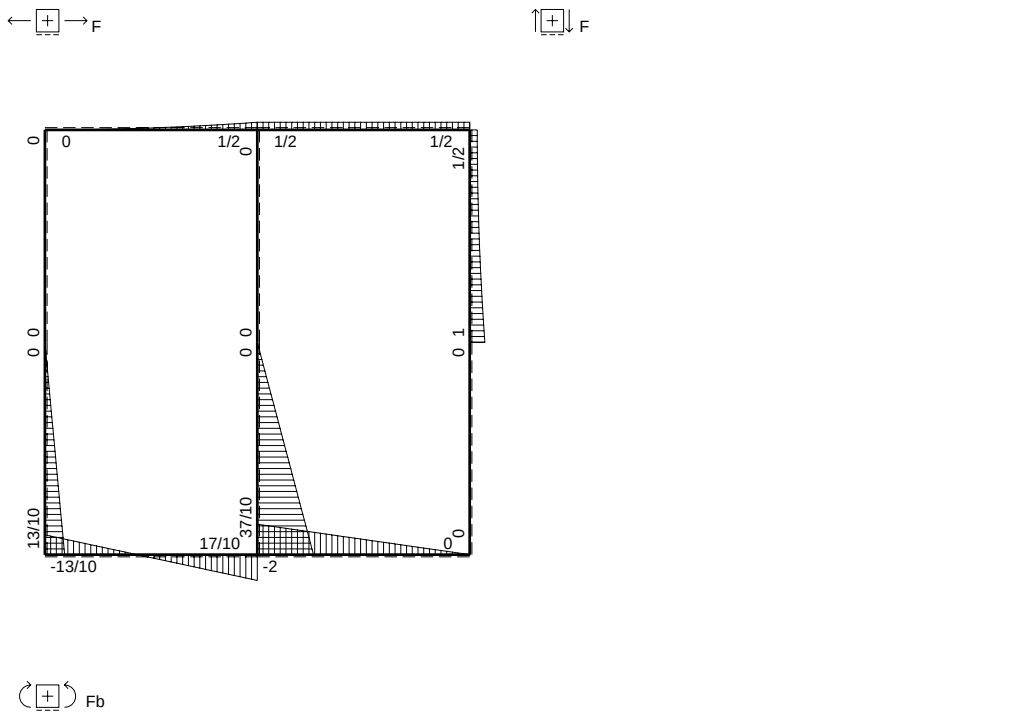
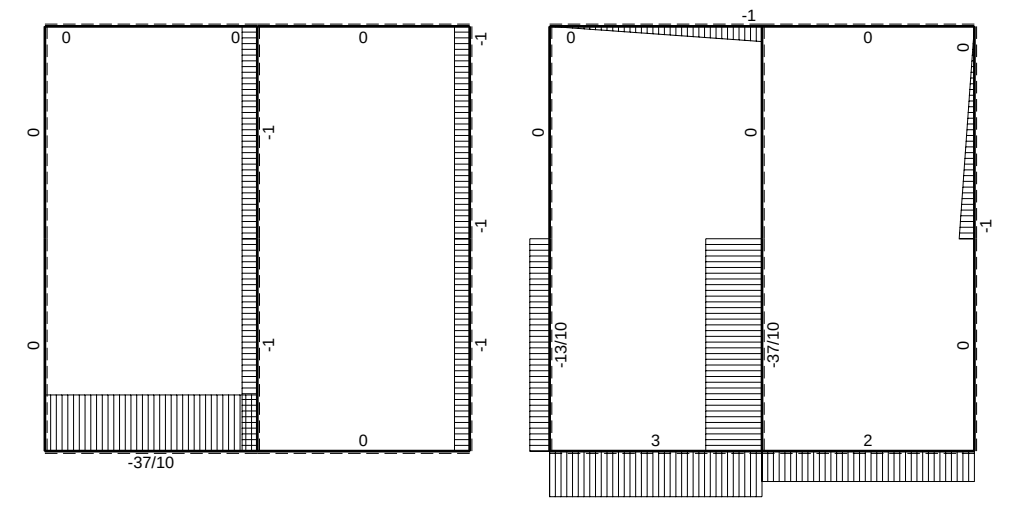
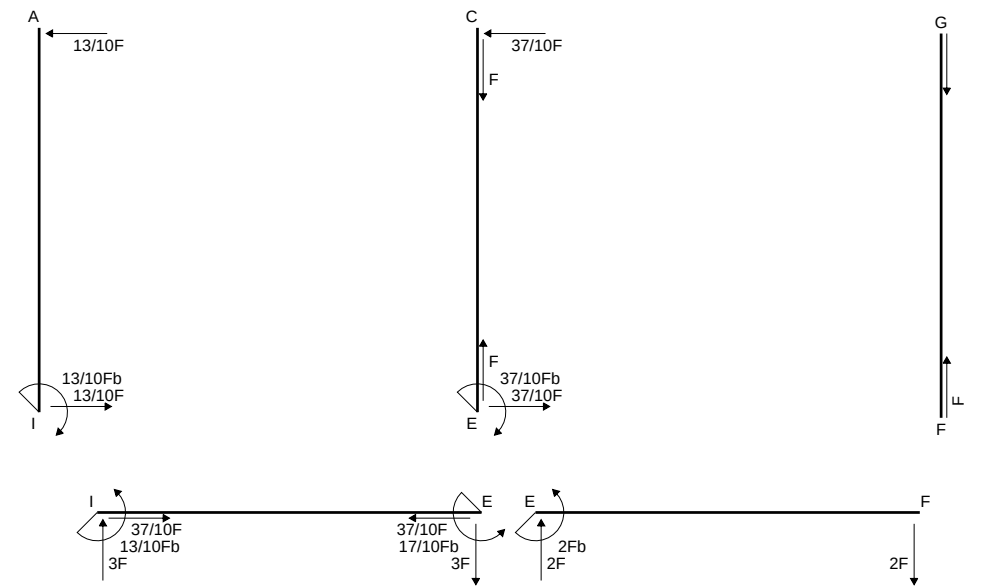
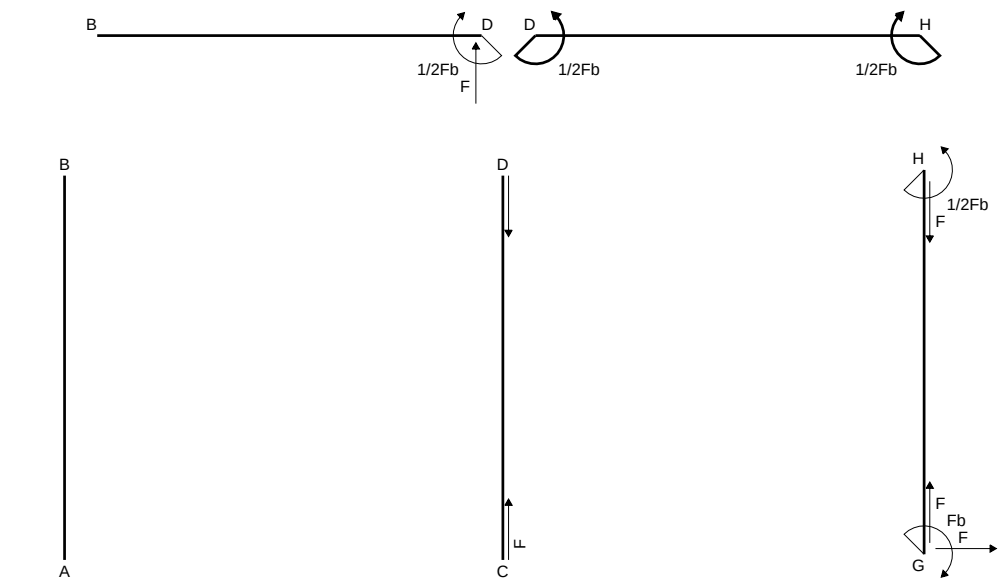
$$v_c = -24.28 \text{ mm}$$

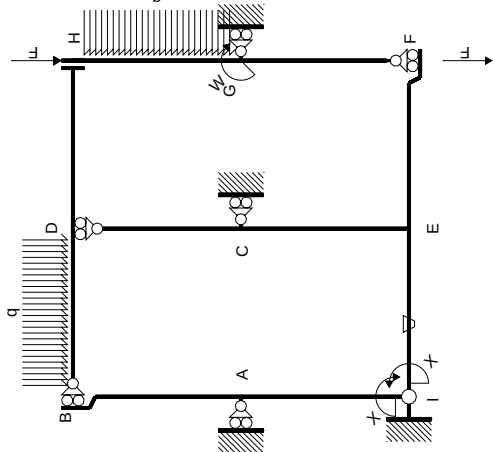
$$\sigma_c = -Mv/J_u = -149.4 \text{ N/mm}^2$$

$$\tau_c = 4.388 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 149.6 \text{ N/mm}^2$$

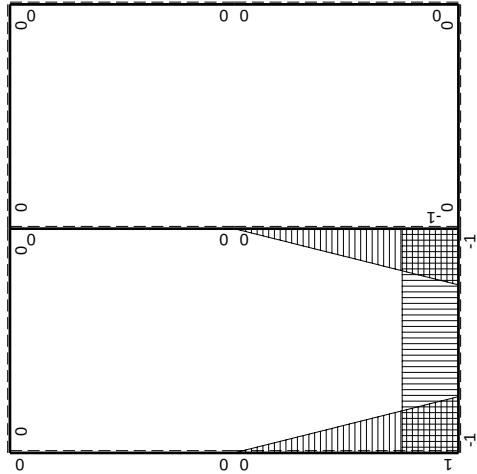
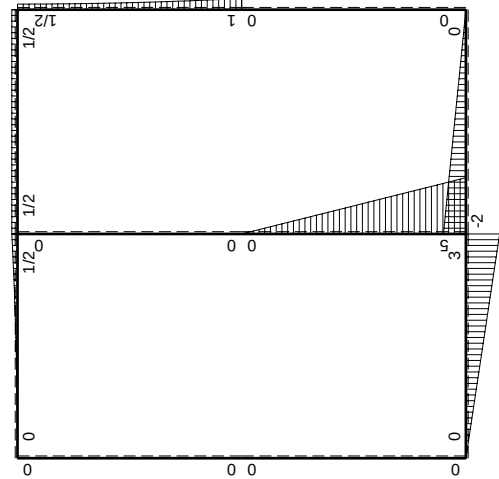
$$S = 3466. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

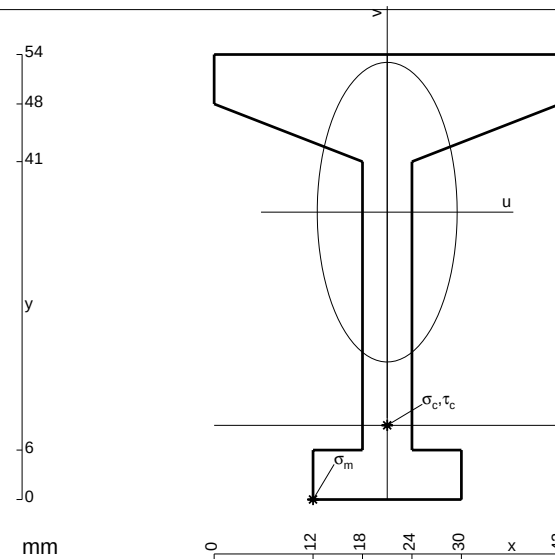
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

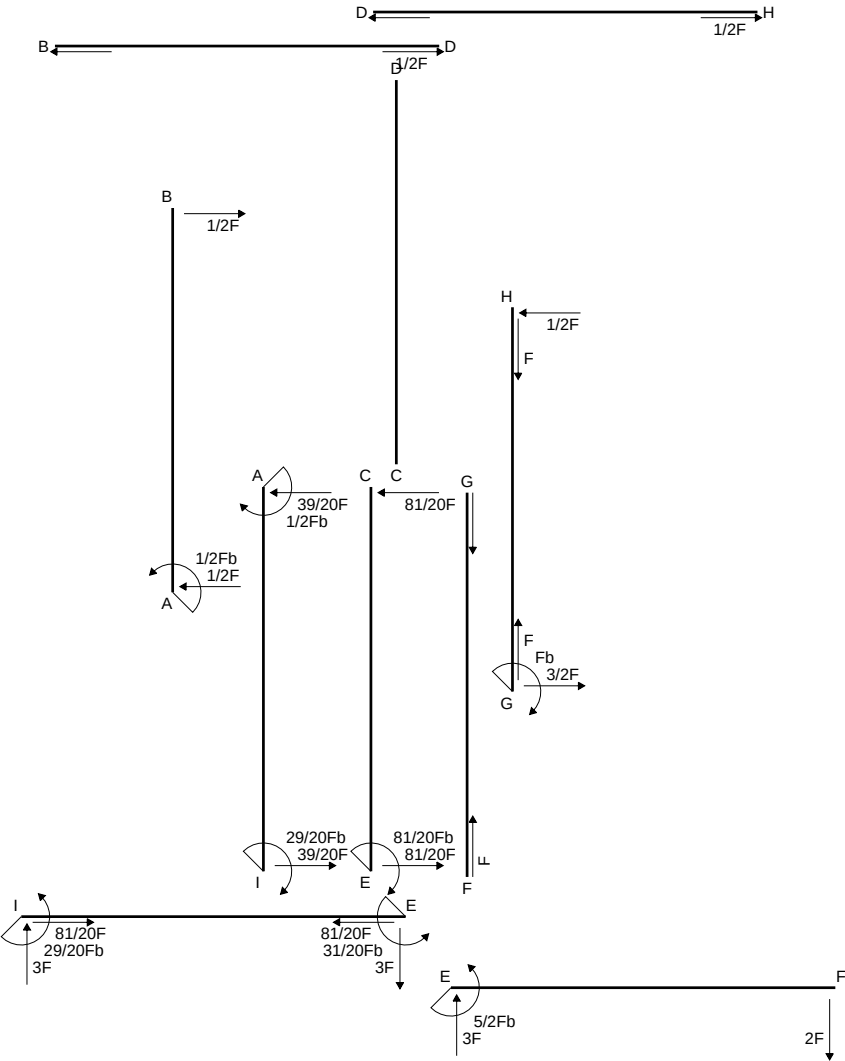
$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$



$$\begin{aligned} A &= 738. \text{ mm}^2 \\ J_u &= 244023. \text{ mm}^4 \\ J_v &= 53190. \text{ mm}^4 \\ y_g &= 34.87 \text{ mm} \\ T_y &= 1700. \text{ N} \\ M_x &= -1462000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -9. \text{ mm} \\ v_m &= -34.87 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -25.87 \text{ mm} \\ \sigma_c &= -Mv/J_u = -155. \text{ N/mm}^2 \\ \tau_c &= 4.568 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 155.2 \text{ N/mm}^2 \\ S &= 3935. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

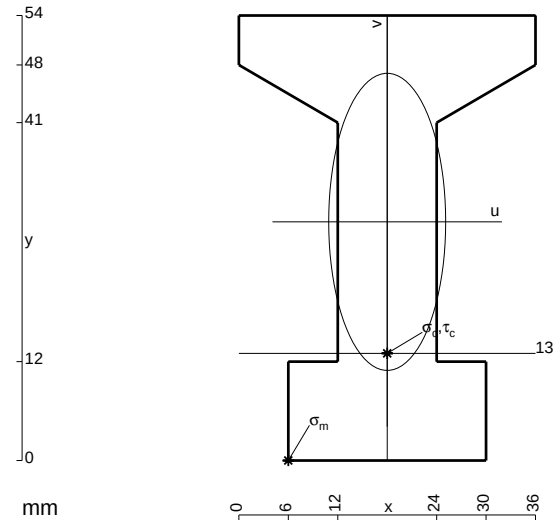
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1020. \text{ mm}^2$$

$$J_u = 331648. \text{ mm}^4$$

$$J_v = 51408. \text{ mm}^4$$

$$y_g = 28.96 \text{ mm}$$

$$T_y = 3300. \text{ N}$$

$$M_x = -2502500. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.96 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218.5 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

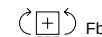
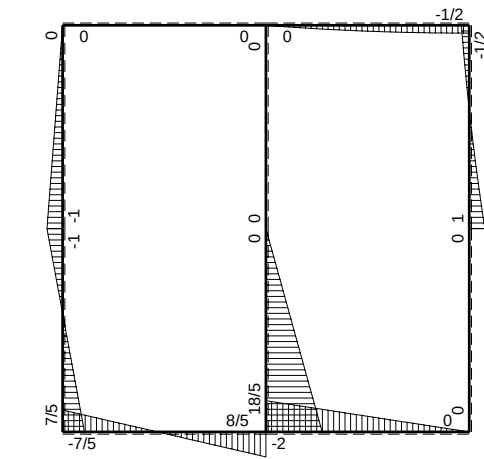
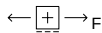
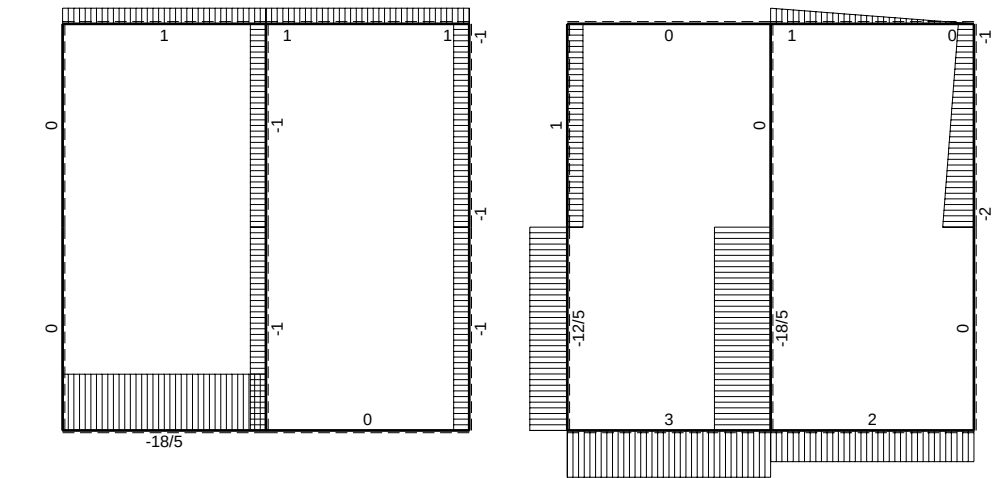
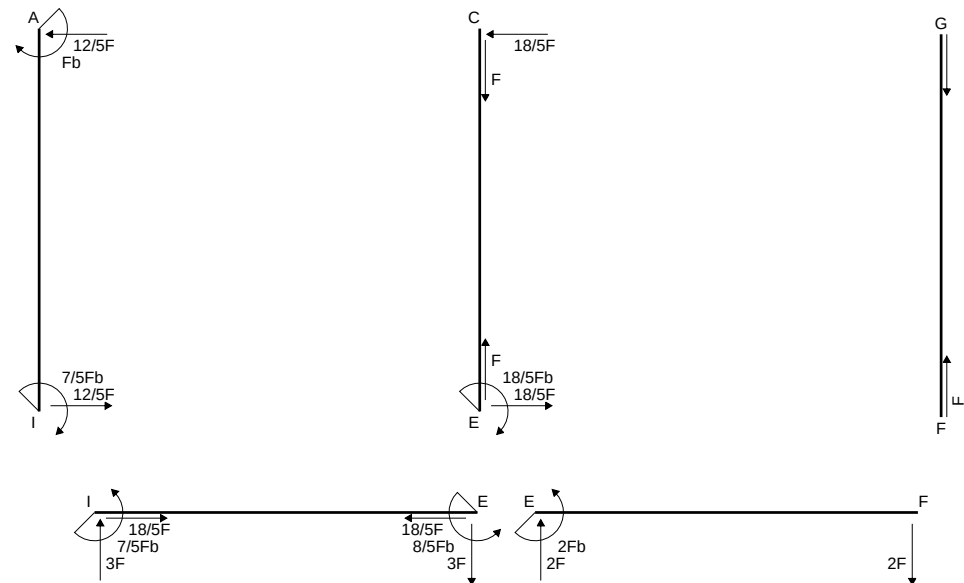
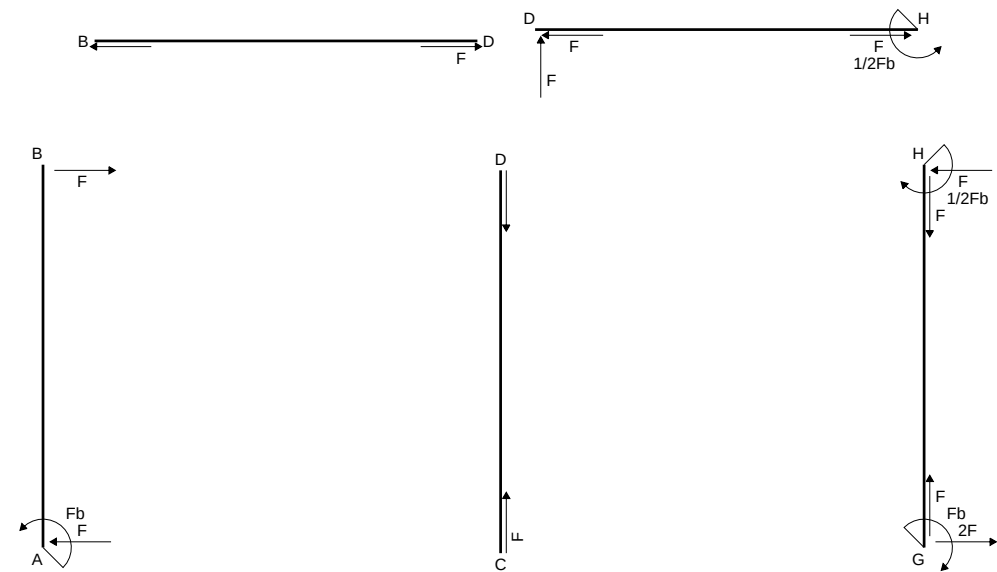
$$v_c = -15.96 \text{ mm}$$

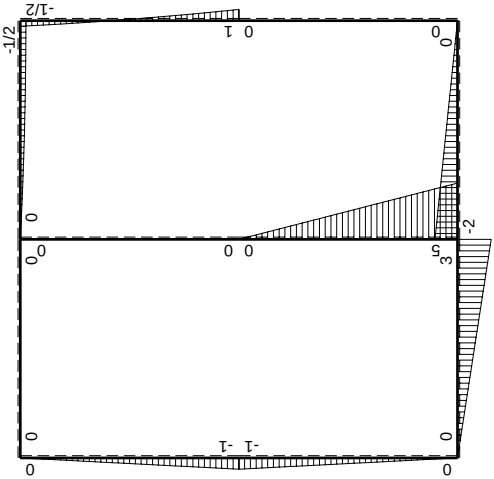
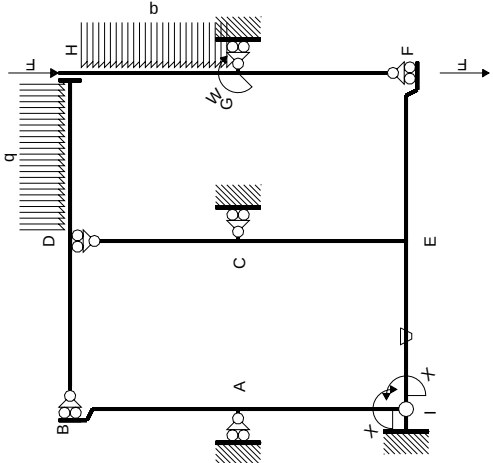
$$\sigma_c = -Mv/J_u = -120.4 \text{ N/mm}^2$$

$$\tau_c = 5.647 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 120.8 \text{ N/mm}^2$$

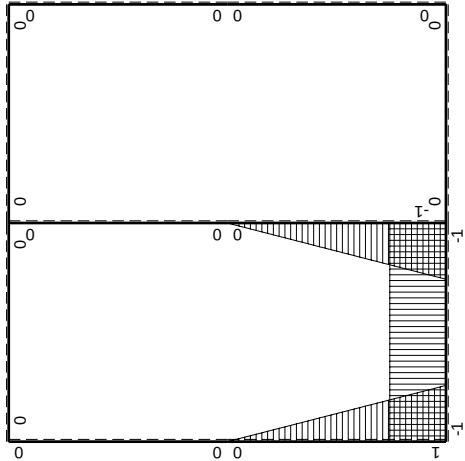
$$S = 6810. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x (M_o/EJ + \theta) dx$	$\int X M_x M_x / EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

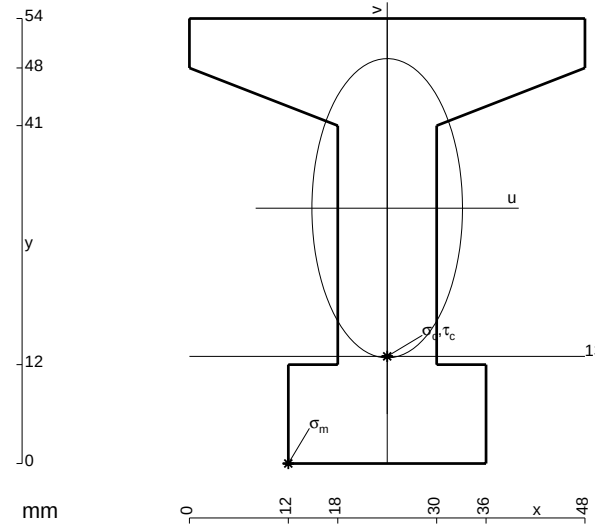
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1134. \text{ mm}^2$$

$$J_u = 374055. \text{ mm}^4$$

$$J_v = 94716. \text{ mm}^4$$

$$y_g = 30.98 \text{ mm}$$

$$T_y = 2860. \text{ N}$$

$$M_x = -2774200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.98 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

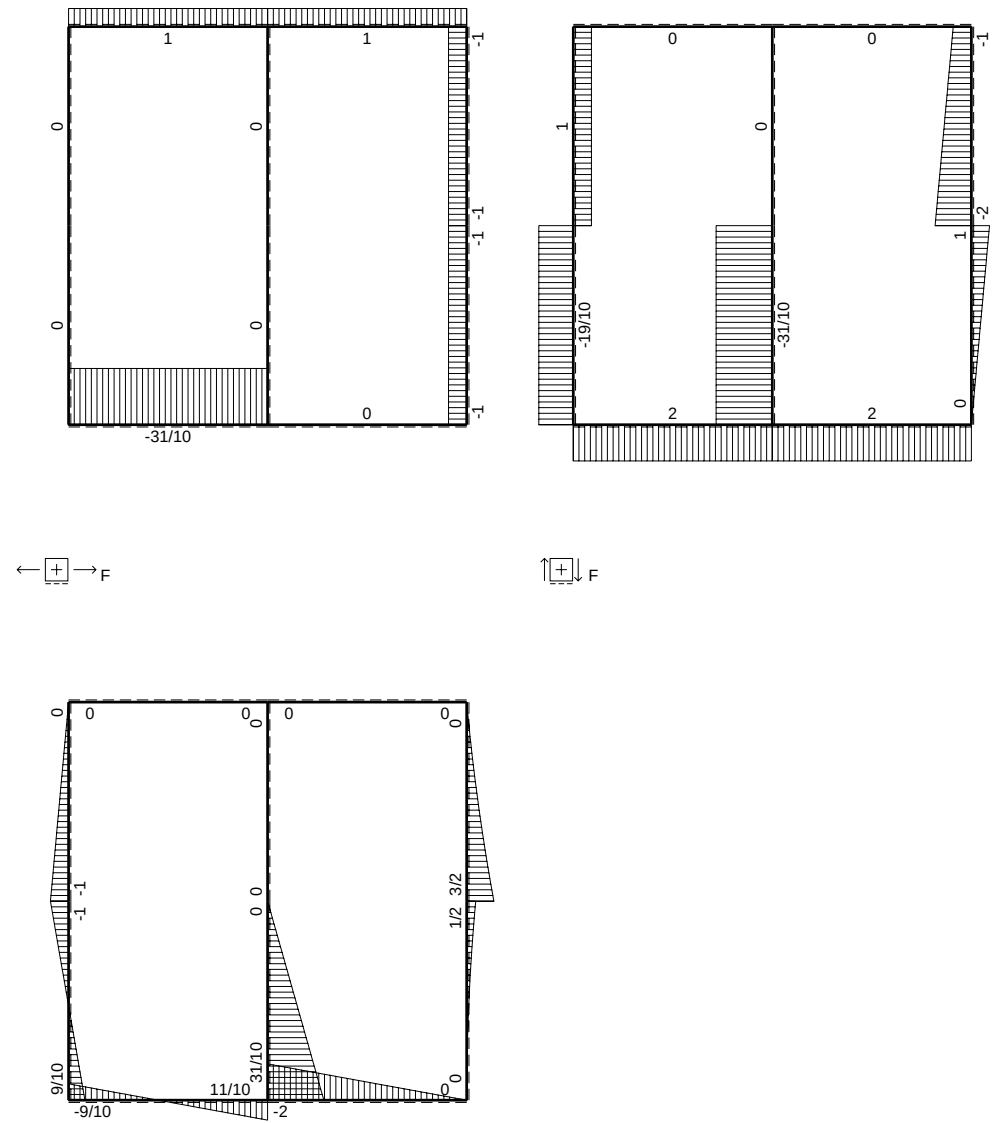
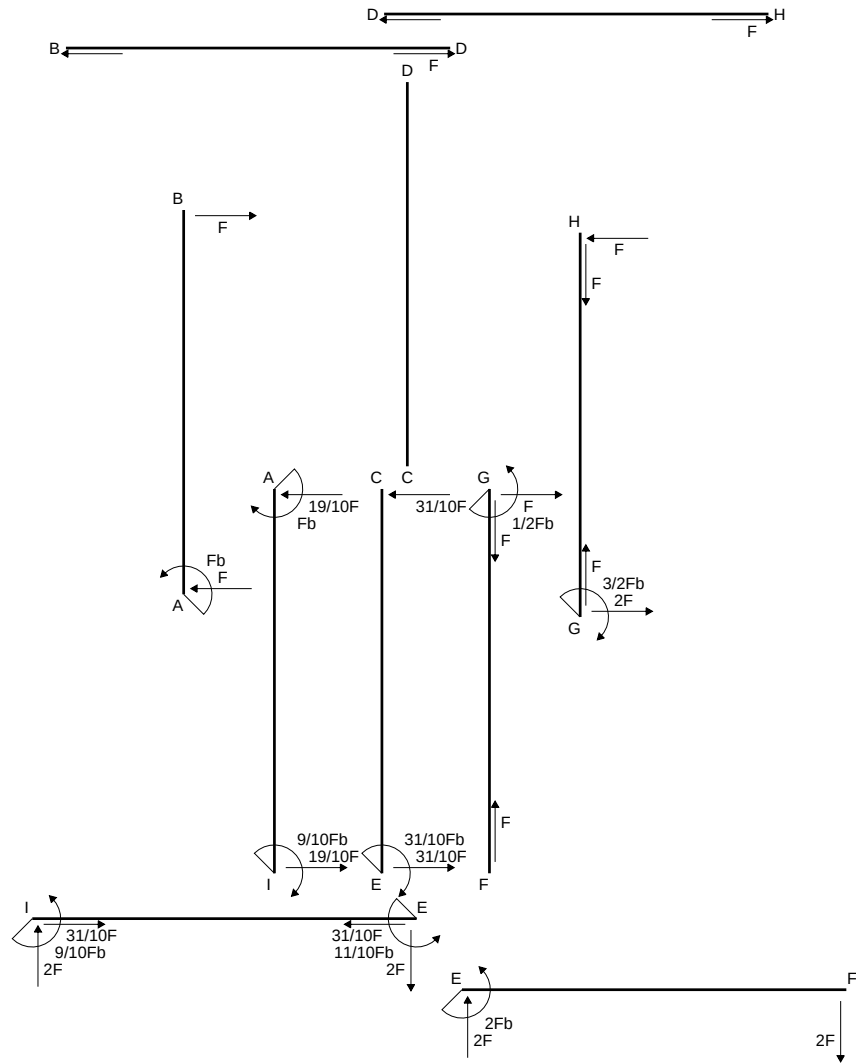
$$v_c = -17.98 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -133.3 \text{ N/mm}^2$$

$$\tau_c = 4.725 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 133.6 \text{ N/mm}^2$$

$$S = 7416. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

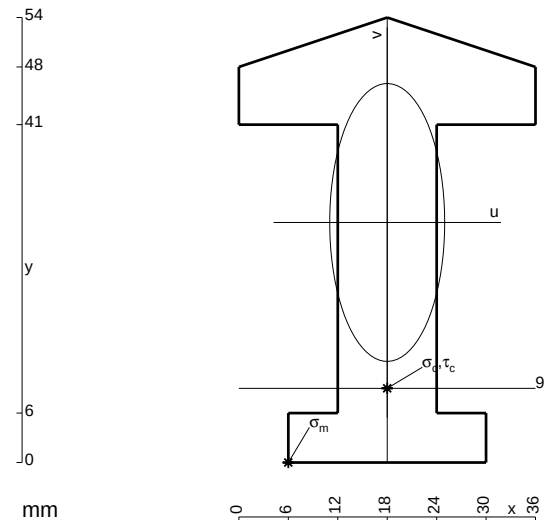
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

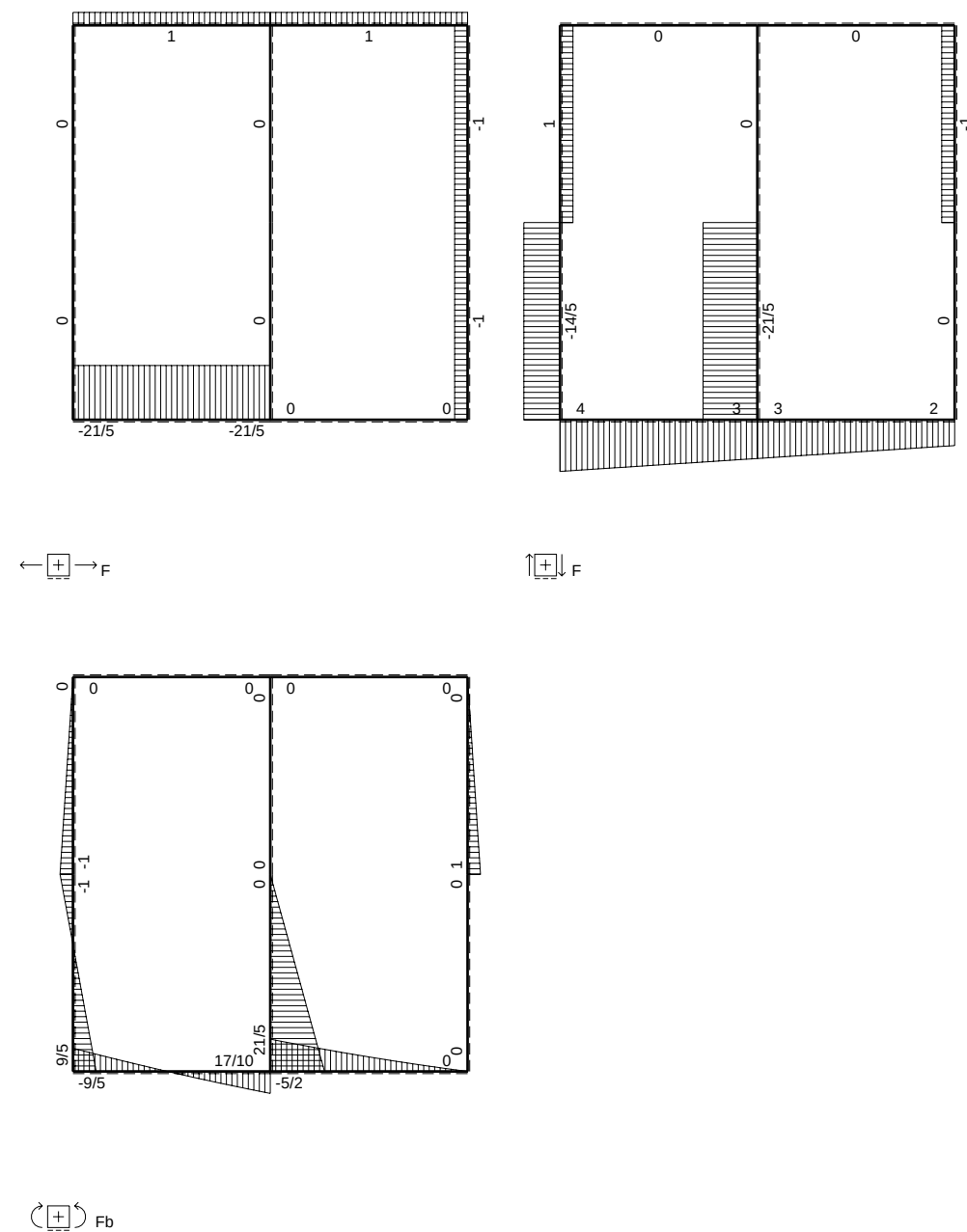
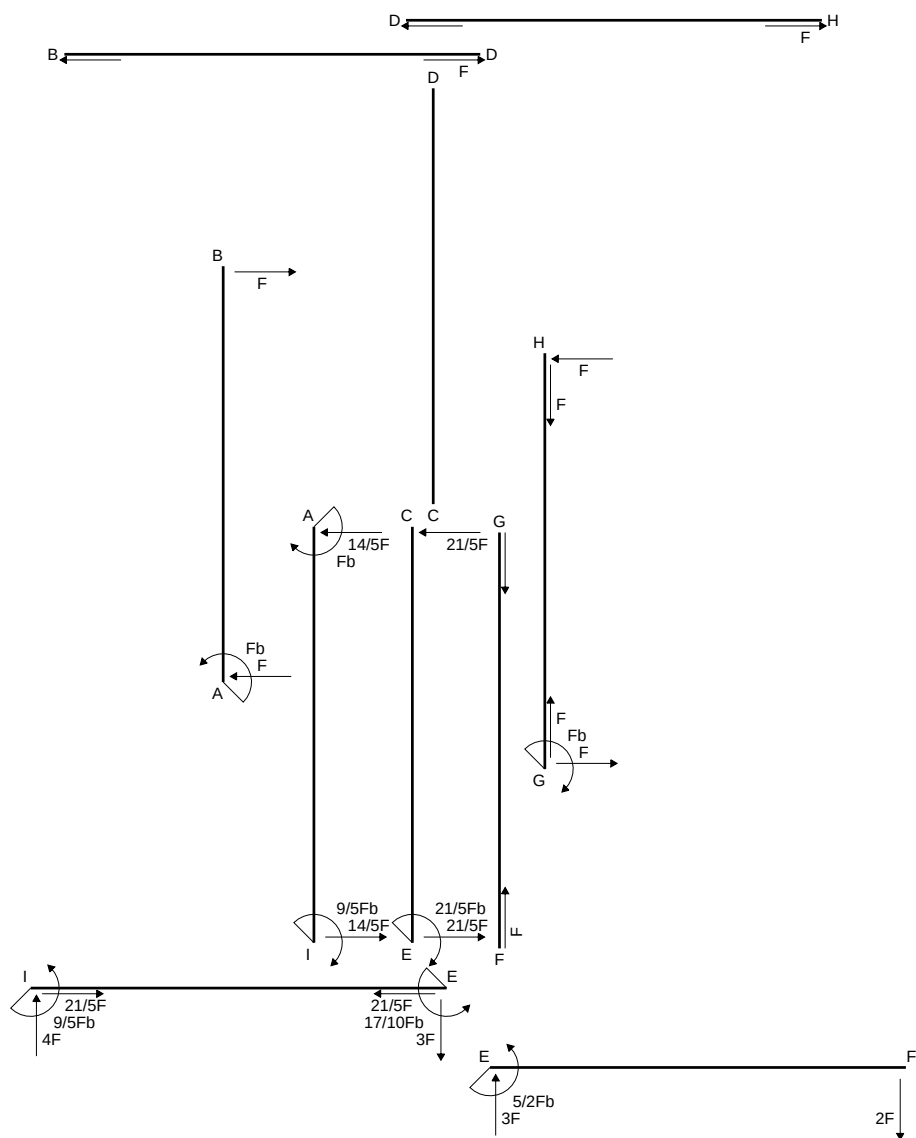
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$\begin{aligned} A &= 924. \text{ mm}^2 \\ J_u &= 262756. \text{ mm}^4 \\ J_v &= 45000. \text{ mm}^4 \\ y_g &= 29.13 \text{ mm} \\ T_y &= 2120. \text{ N} \\ M_x &= -2162400. \text{ Nmm} \\ x_m &= 6. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.13 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.7 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 9. \text{ mm} \\ v_c &= -20.13 \text{ mm} \\ \sigma_c &= -Mv/J_u = -165.7 \text{ N/mm}^2 \\ \tau_c &= 3.053 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 165.7 \text{ N/mm}^2 \\ S &= 4541. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	-Fb/EJ	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

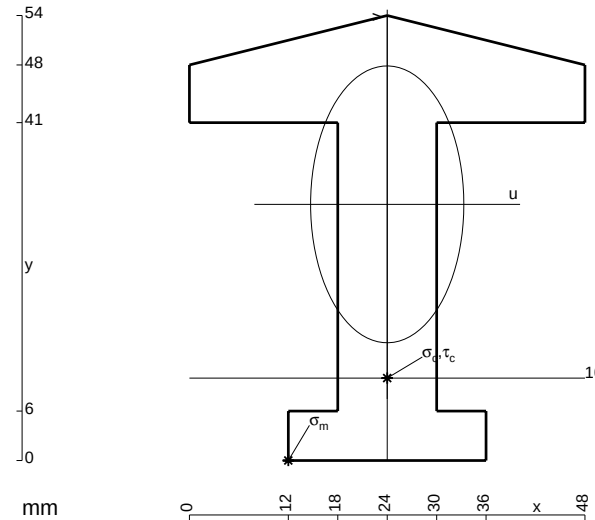
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

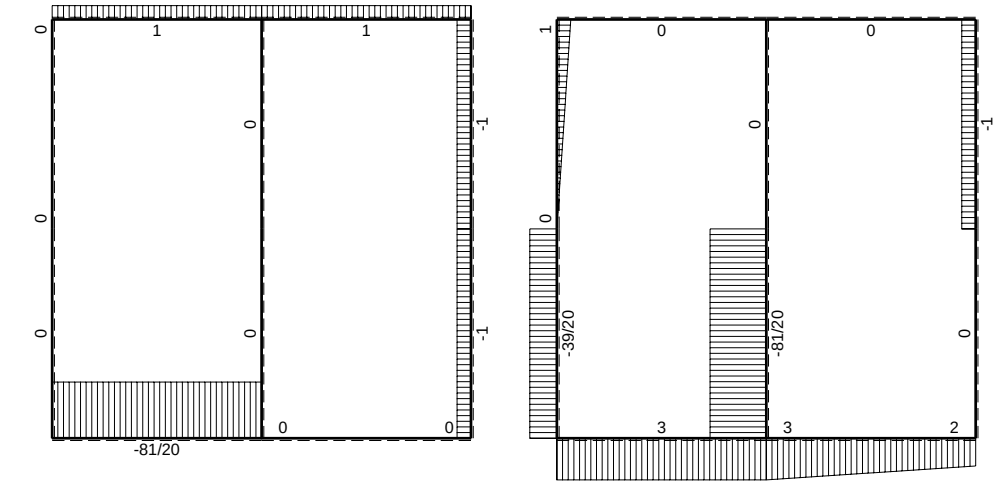
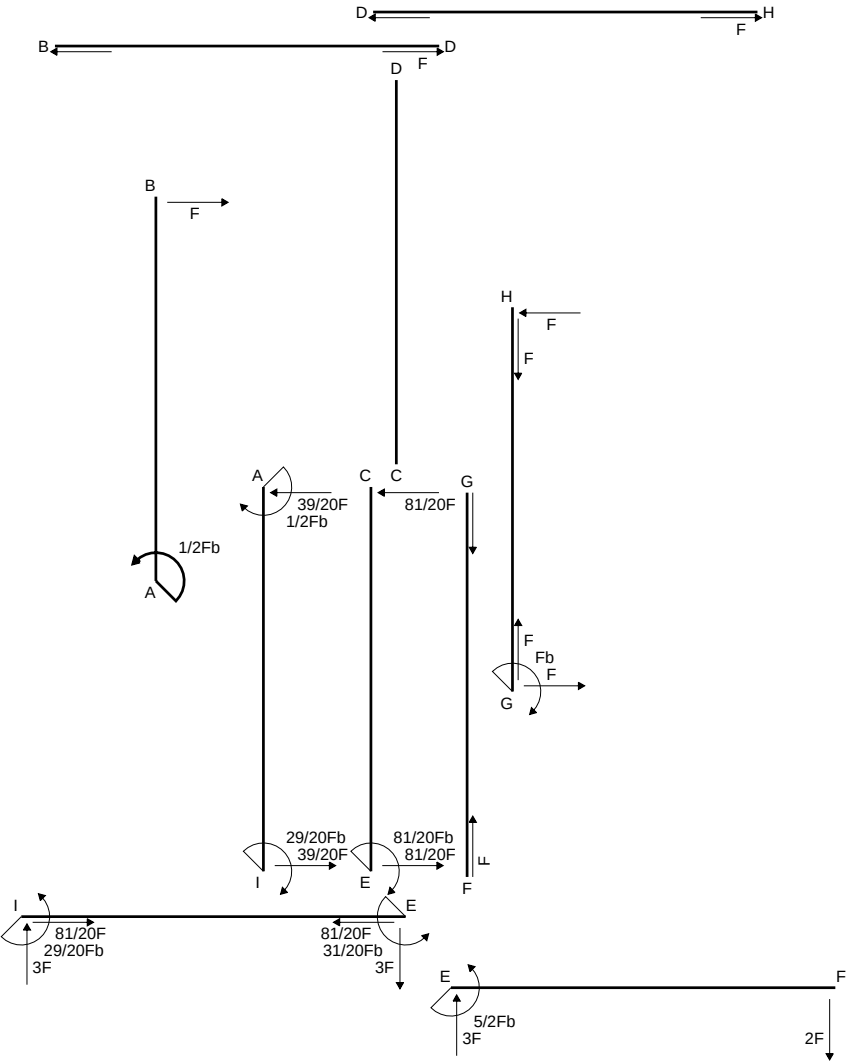
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

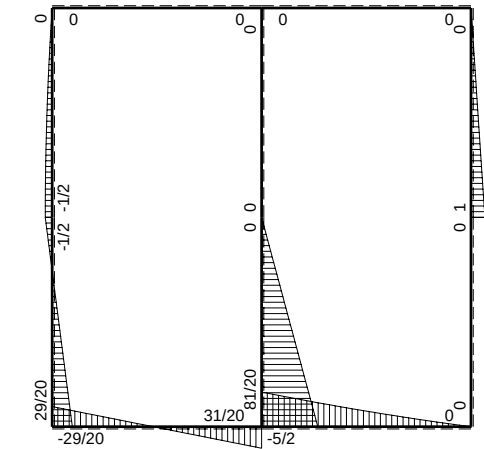


$$\begin{aligned} A &= 1044. \text{ mm}^2 \\ J_u &= 294700. \text{ mm}^4 \\ J_v &= 90288. \text{ mm}^4 \\ y_g &= 31.09 \text{ mm} \\ T_y &= 4200. \text{ N} \\ M_x &= -1890000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.09 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -21.09 \text{ mm} \\ \sigma_c &= -Mv/J_u = -135.2 \text{ N/mm}^2 \\ \tau_c &= 6.119 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 135.6 \text{ N/mm}^2 \\ S &= 5153. \text{ mm}^3 \end{aligned}$$

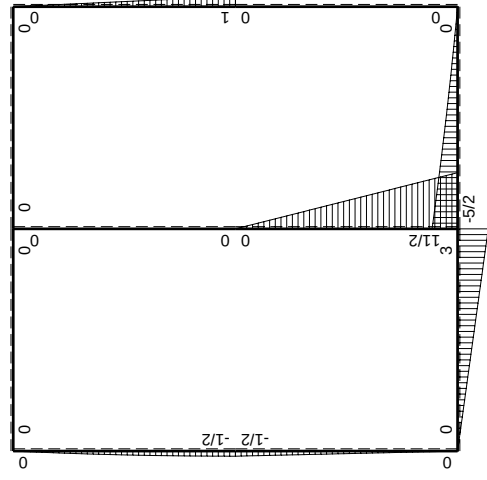
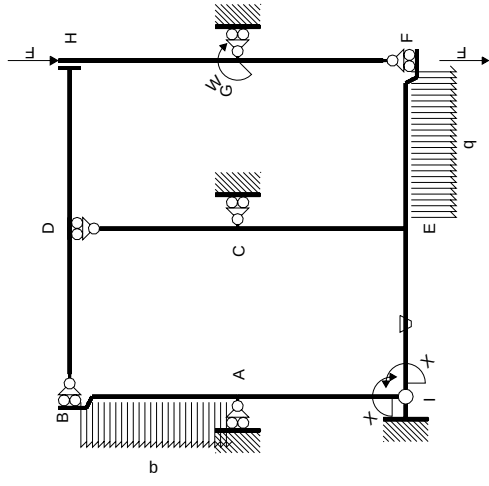


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↑ $\boxed{+}$ ↓ F

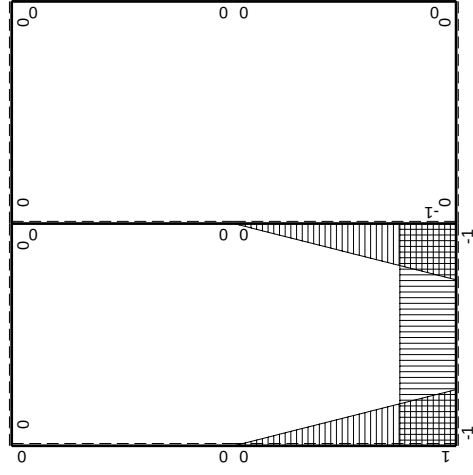


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

 M_o flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

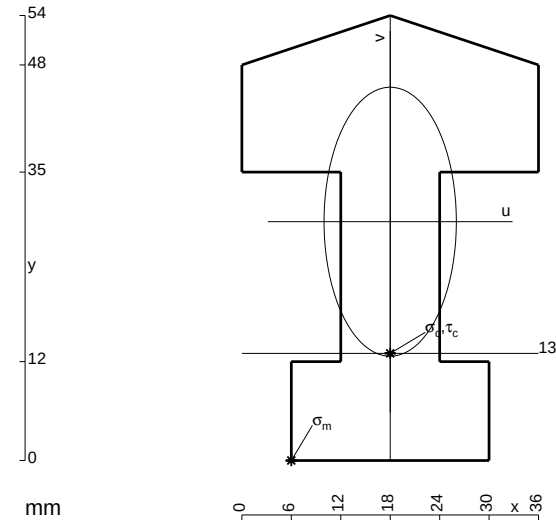
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1140. \text{ mm}^2$$

$$J_u = 303884. \text{ mm}^4$$

$$J_v = 73512. \text{ mm}^4$$

$$y_g = 28.98 \text{ mm}$$

$$T_y = 4470. \text{ N}$$

$$M_x = -2197750. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.98 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

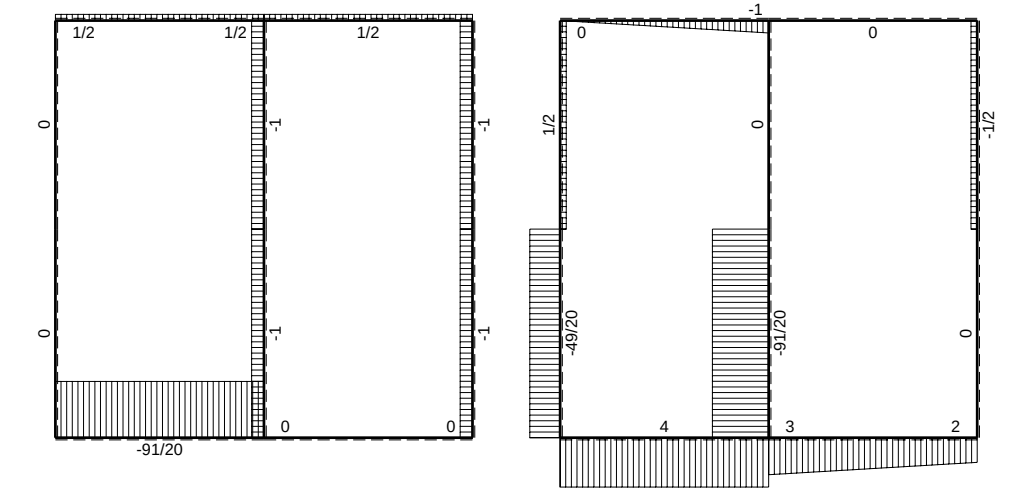
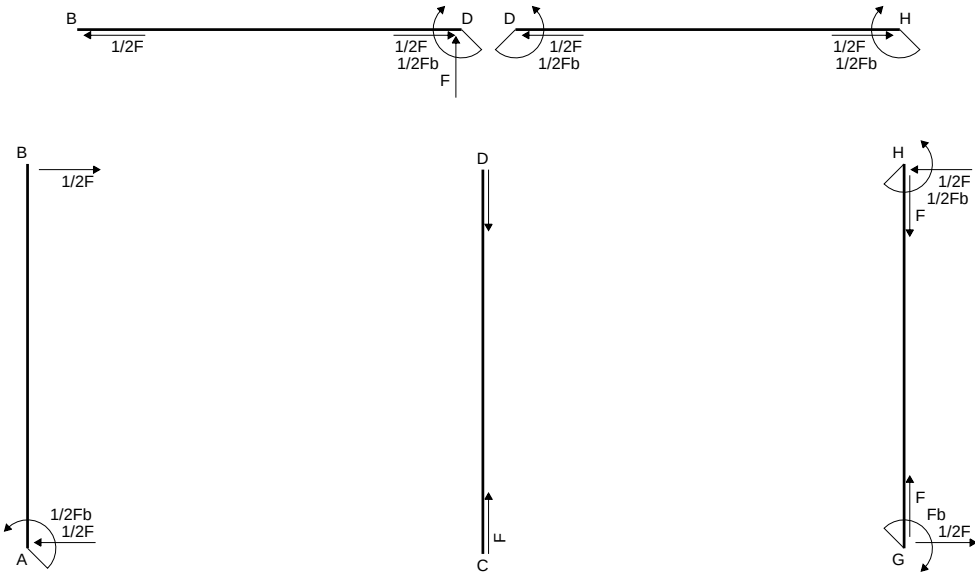
$$v_c = -15.98 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -115.6 \text{ N/mm}^2$$

$$\tau_c = 8.355 \text{ N/mm}^2$$

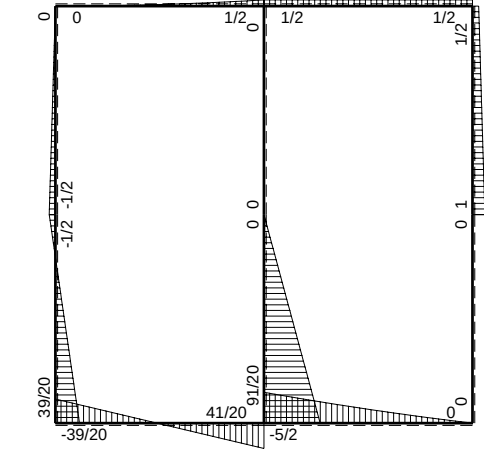
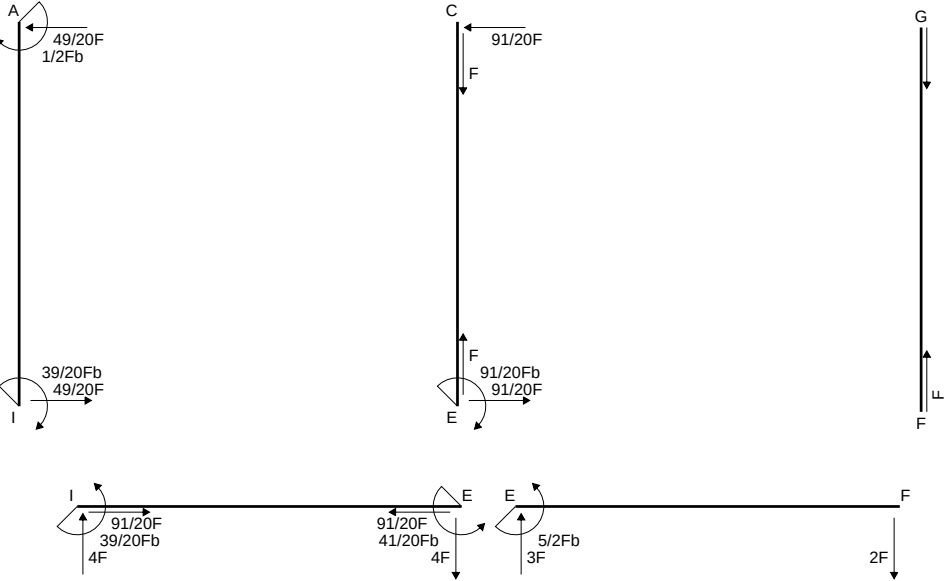
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 116.5 \text{ N/mm}^2$$

$$S = 6816. \text{ mm}^3$$

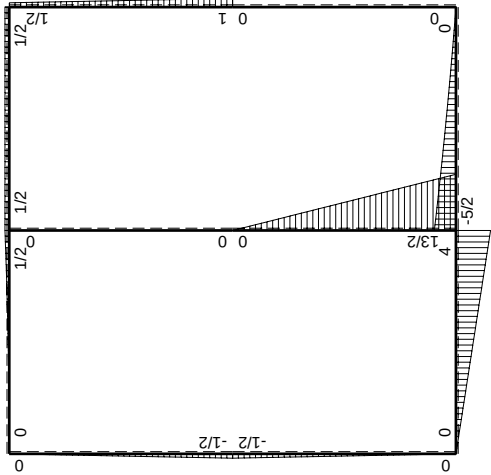
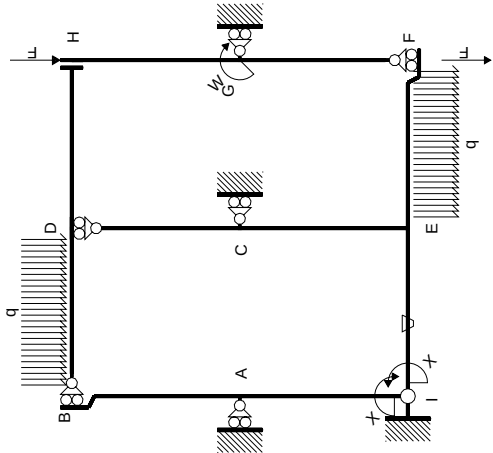


← ⊕ → F

↑ ⊕ ↓ F

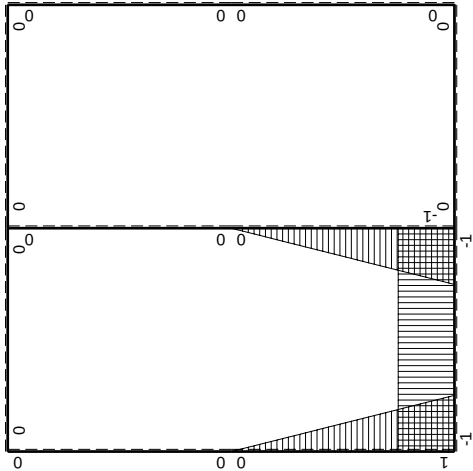


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-13/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$39/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

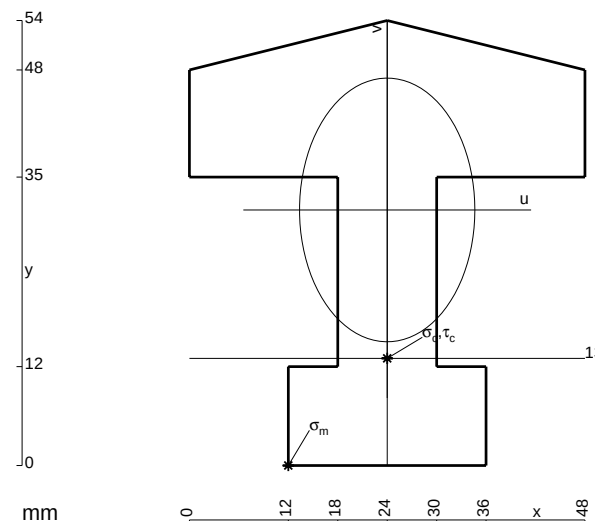
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

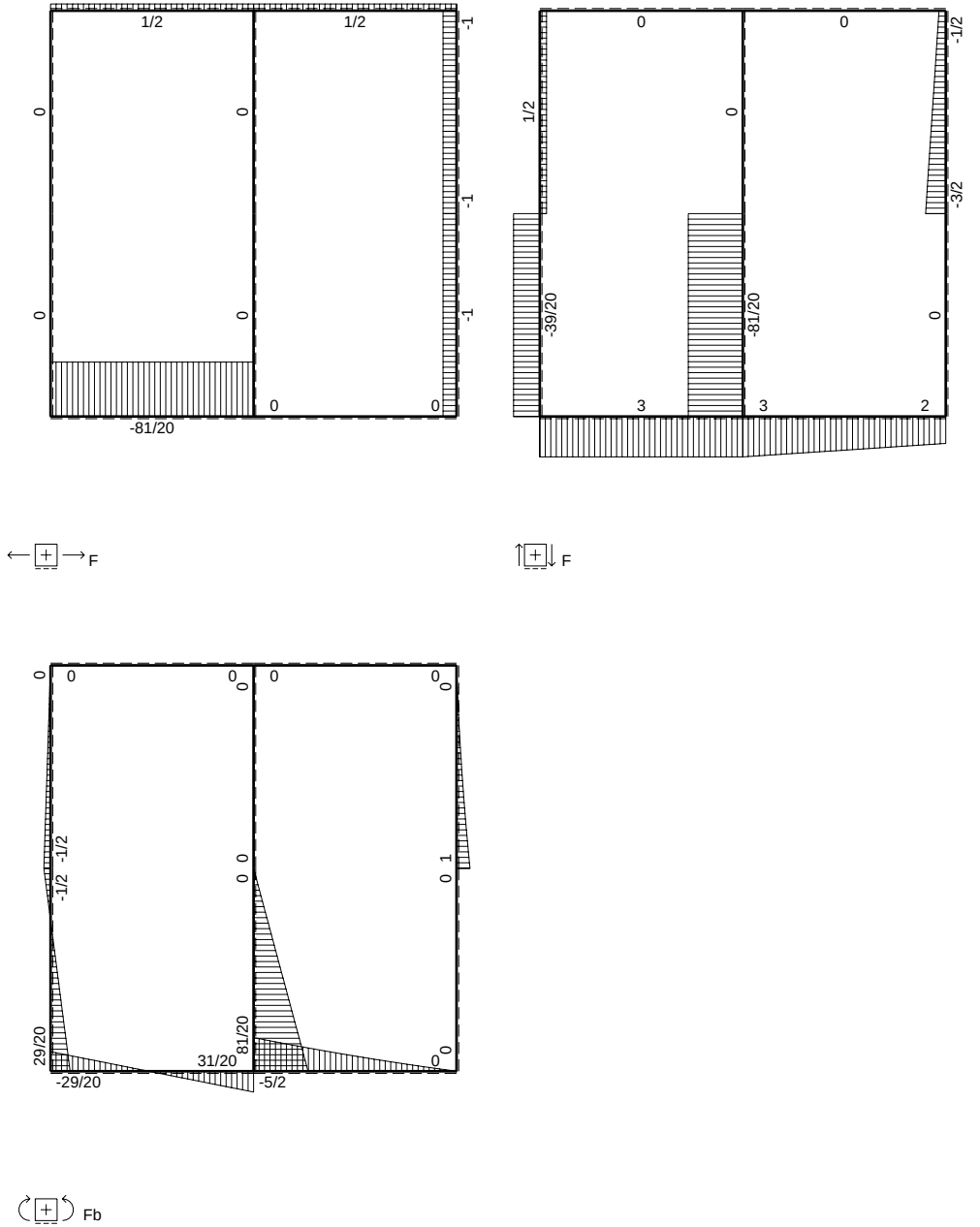
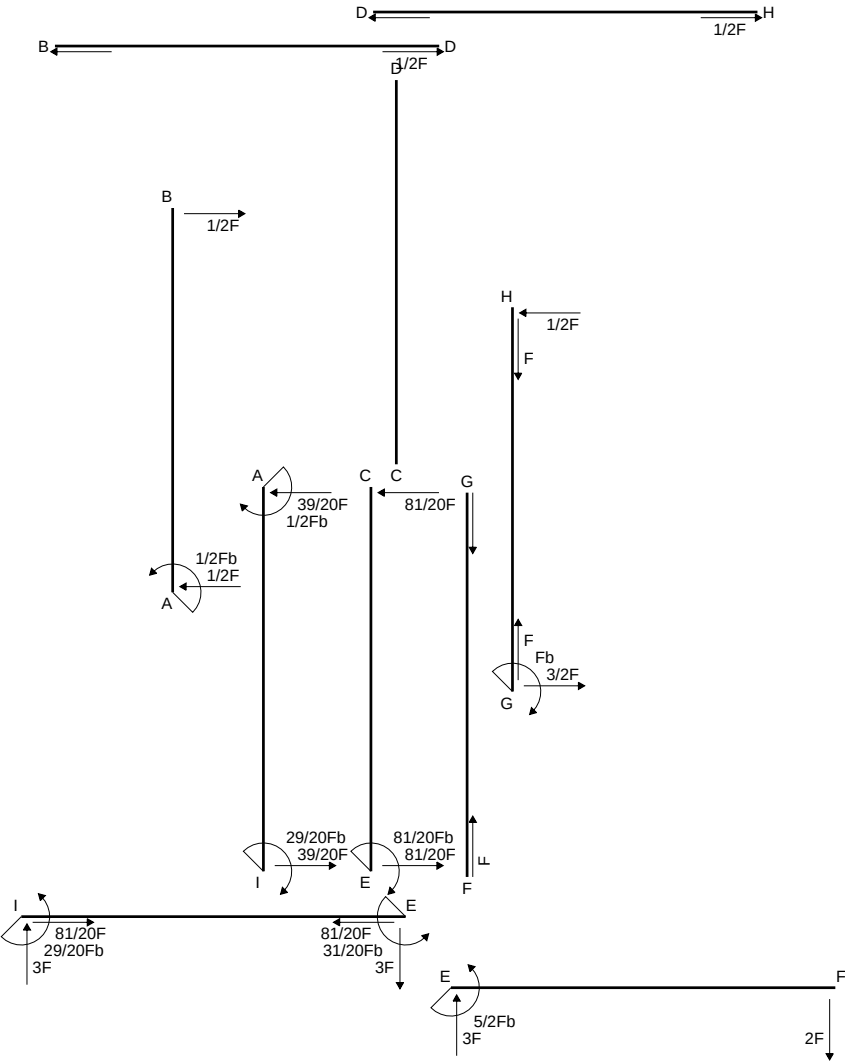
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$\begin{aligned} A &= 1332. \text{ mm}^2 \\ J_u &= 341004. \text{ mm}^4 \\ J_v &= 150768. \text{ mm}^4 \\ y_g &= 31.01 \text{ mm} \\ T_y &= 4530. \text{ N} \\ M_x &= -2416000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.01 \text{ mm} \\ \sigma_m &= -Mv/J_u = -129.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -18.01 \text{ mm} \\ \sigma_c &= -Mv/J_u = -127.6 \text{ N/mm}^2 \\ \tau_c &= 8.221 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 128.4 \text{ N/mm}^2 \\ S &= 7426. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-29/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$29/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

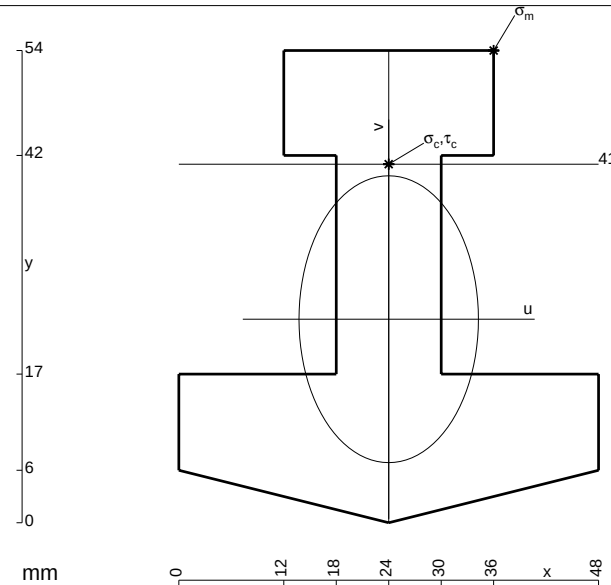
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1260. \text{ mm}^2$$

$$J_u = 339087. \text{ mm}^4$$

$$J_v = 132624. \text{ mm}^4$$

$$y_g = 23.27 \text{ mm}$$

$$T_y = 4350. \text{ N}$$

$$M_x = -2537500. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.73 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 230. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

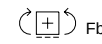
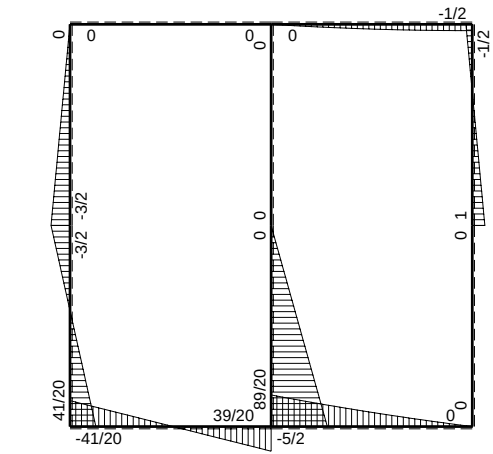
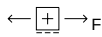
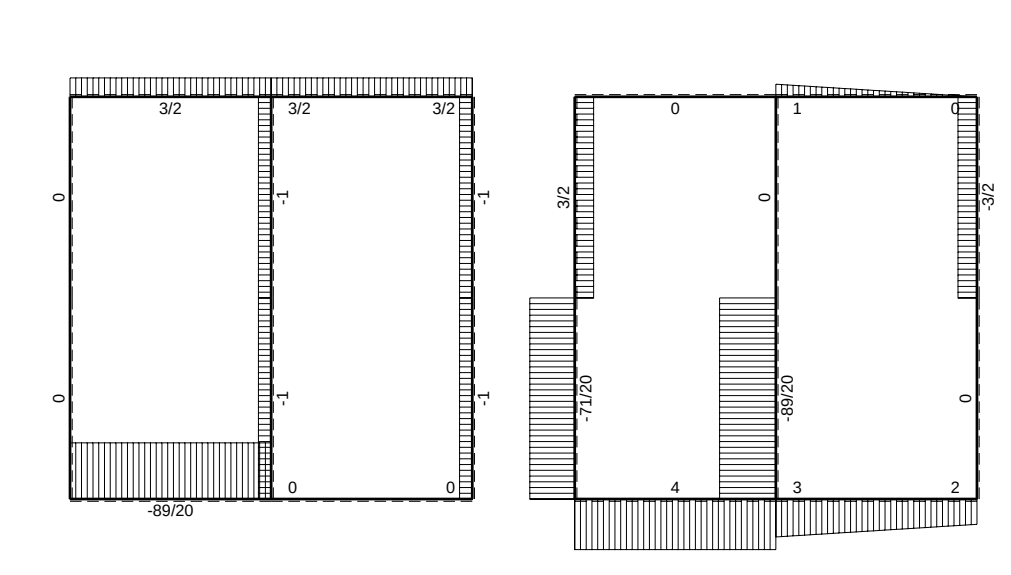
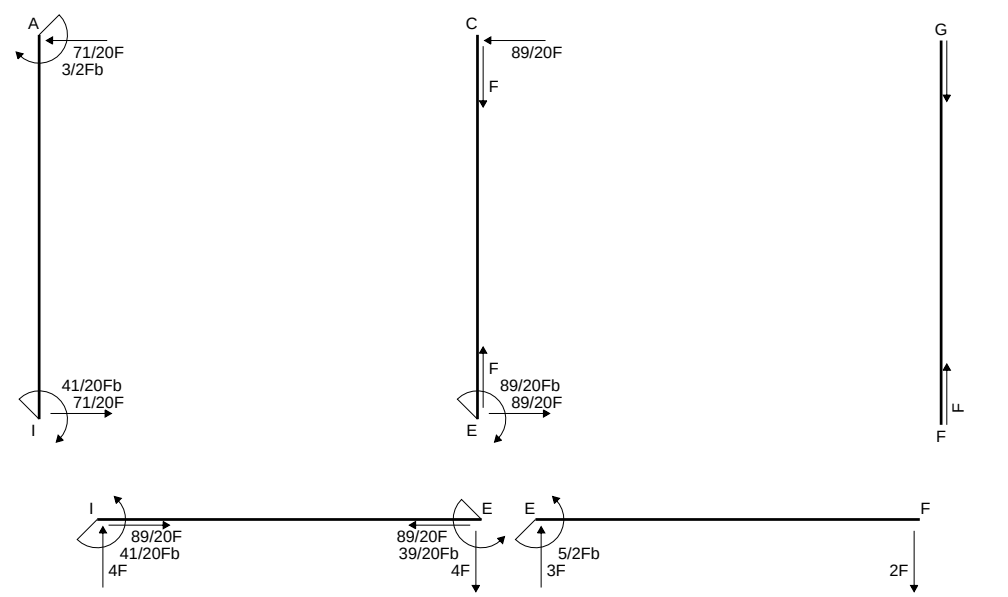
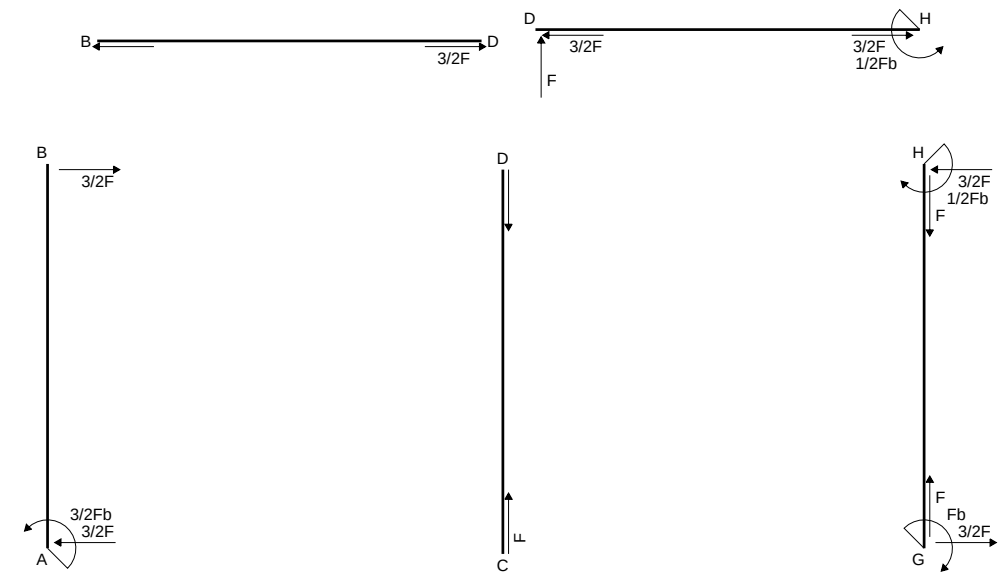
$$v_c = 17.73 \text{ mm}$$

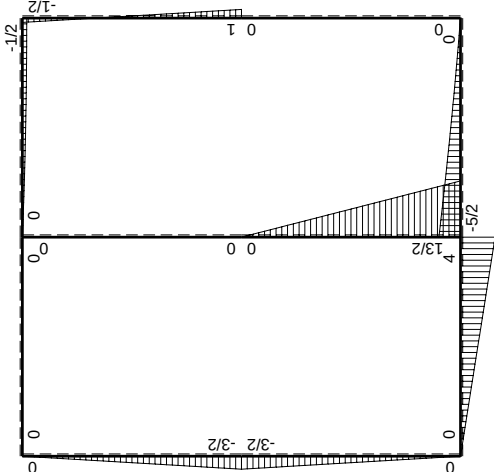
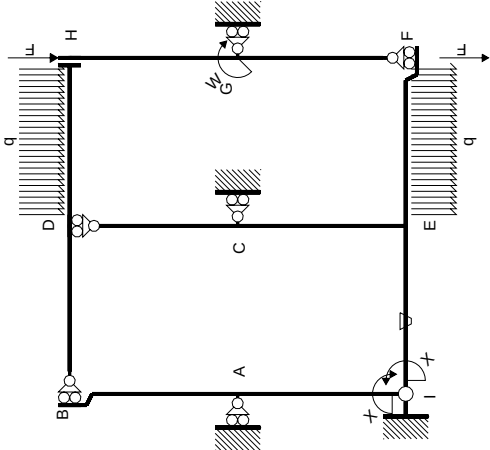
$$\sigma_c = -Mv/J_u = 132.7 \text{ N/mm}^2$$

$$\tau_c = 7.847 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 133.4 \text{ N/mm}^2$$

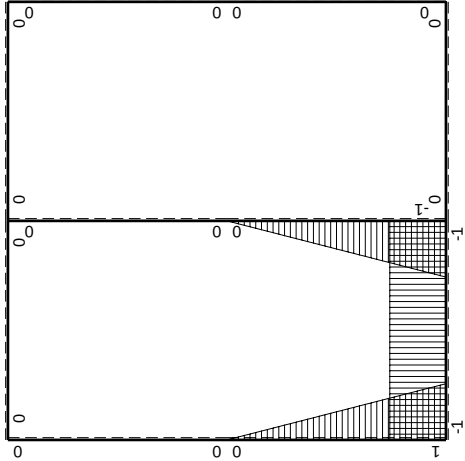
$$S = 7341. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-41/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$41/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

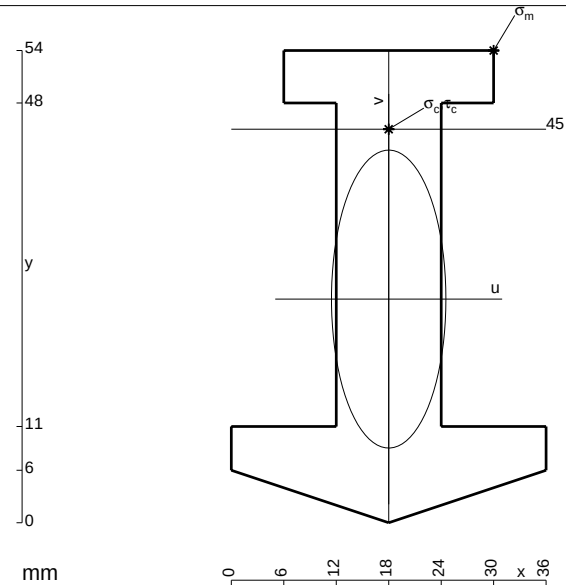
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 876. \text{ mm}^2$$

$$J_u = 254354. \text{ mm}^4$$

$$J_v = 37512. \text{ mm}^4$$

$$y_g = 25.58 \text{ mm}$$

$$T_y = 3420. \text{ N}$$

$$M_x = -2137500. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.42 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.9 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 45. \text{ mm}$$

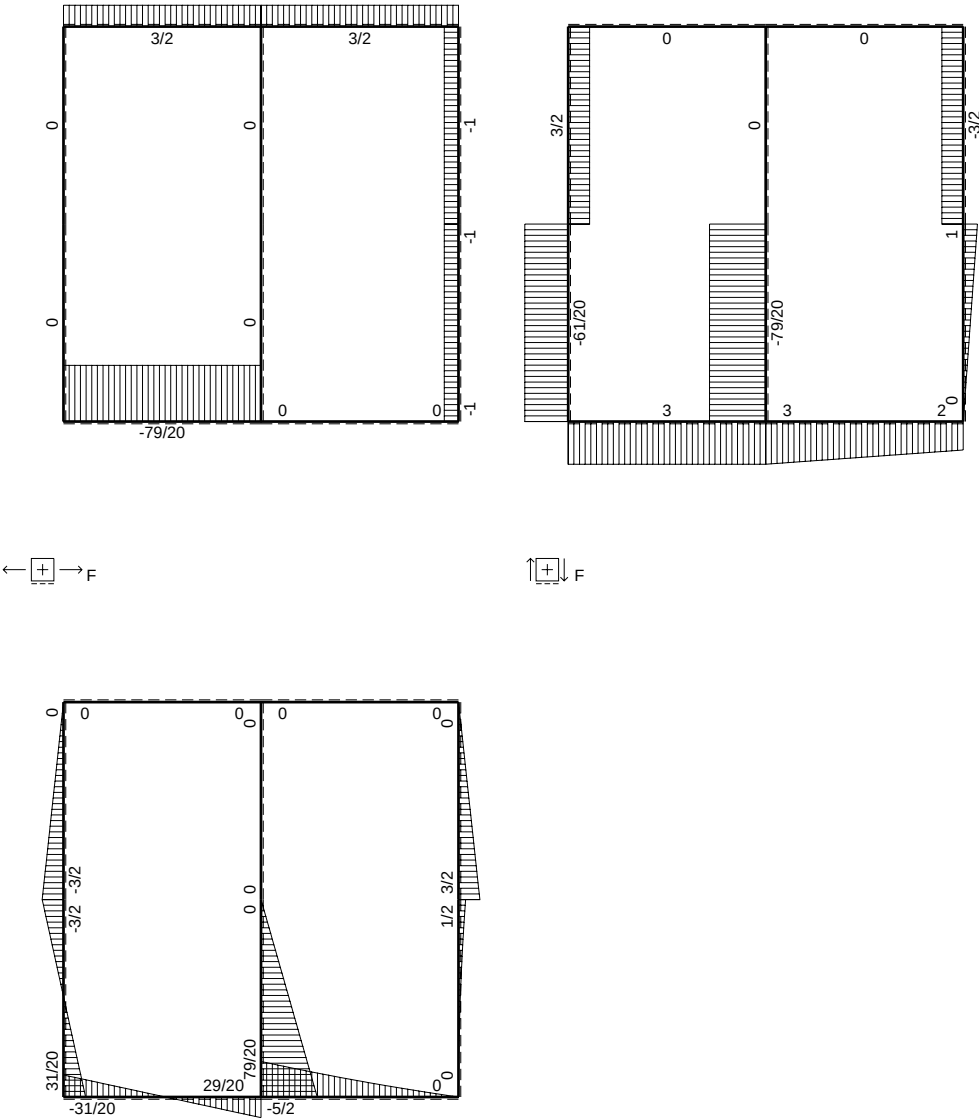
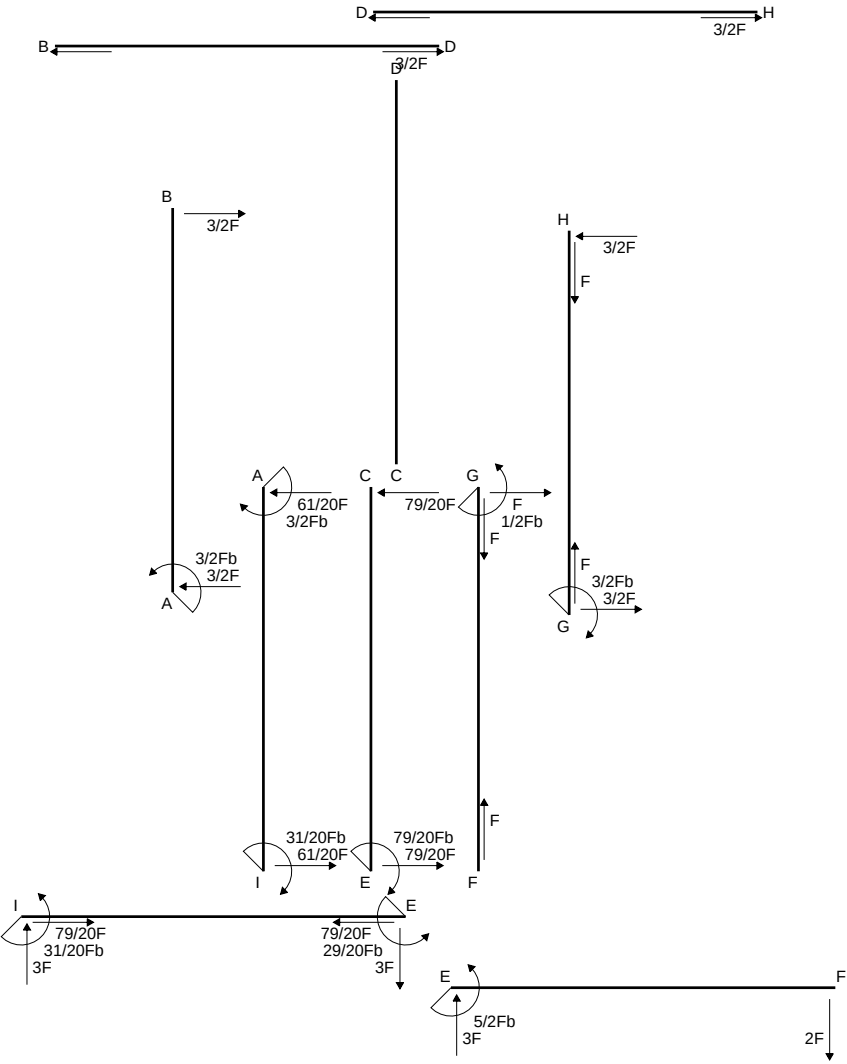
$$v_c = 19.42 \text{ mm}$$

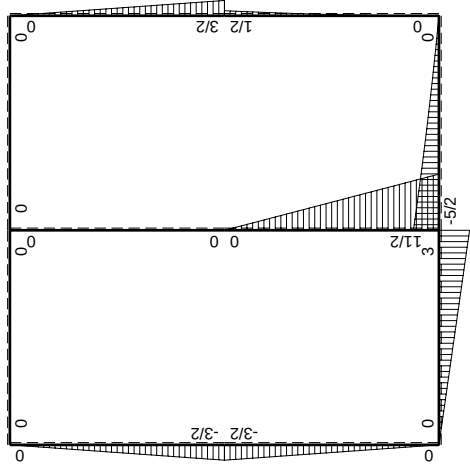
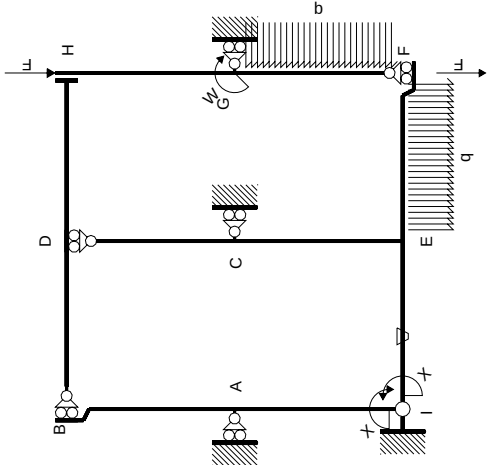
$$\sigma_c = -Mv/J_u = 163.2 \text{ N/mm}^2$$

$$\tau_c = 4.946 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 163.5 \text{ N/mm}^2$$

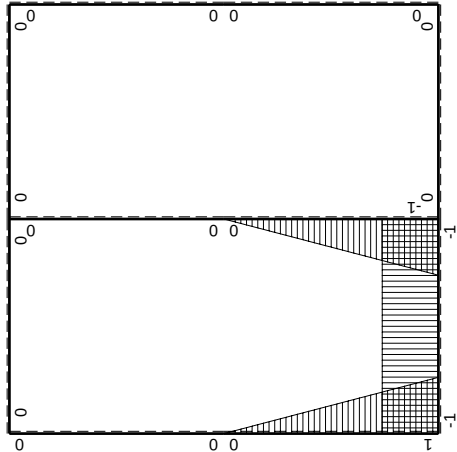
$$S = 4414. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

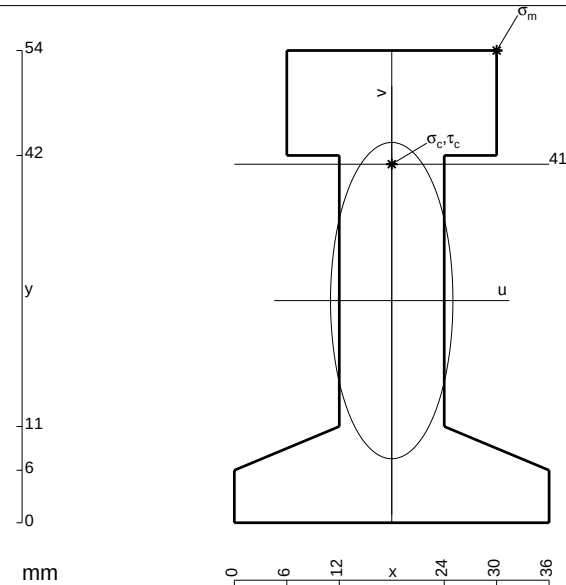
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 996. \text{ mm}^2$$

$$J_u = 326037. \text{ mm}^4$$

$$J_v = 48816. \text{ mm}^4$$

$$y_g = 25.4 \text{ mm}$$

$$T_y = 3360. \text{ N}$$

$$M_x = -2268000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.6 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 198.9 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

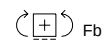
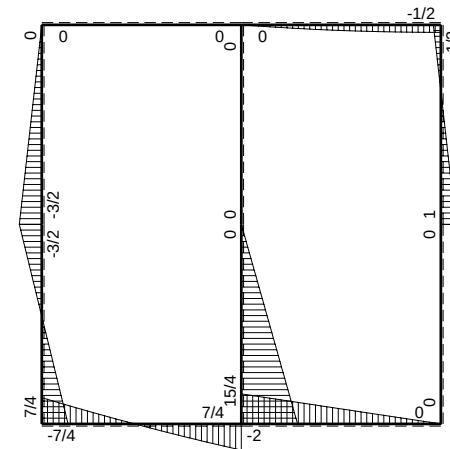
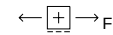
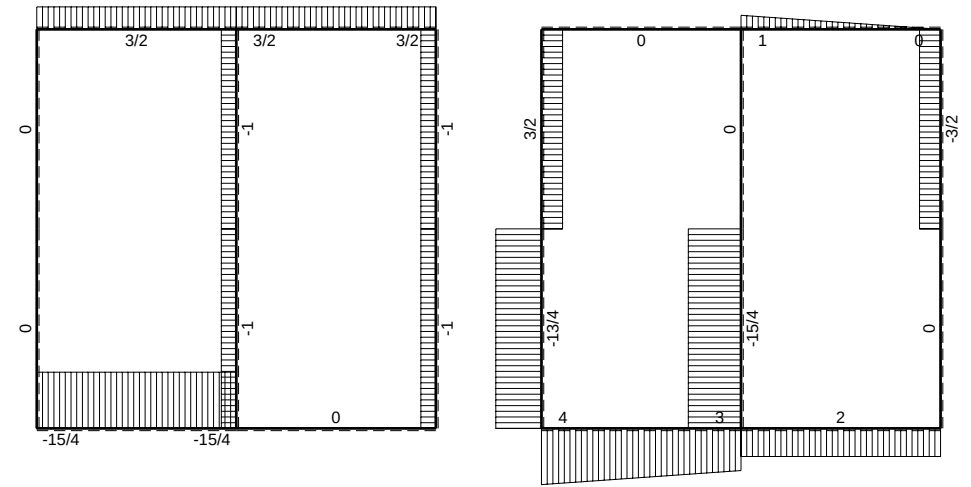
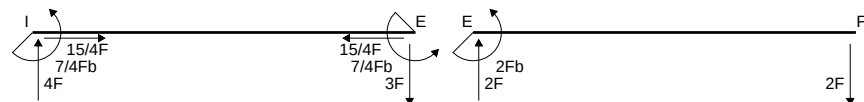
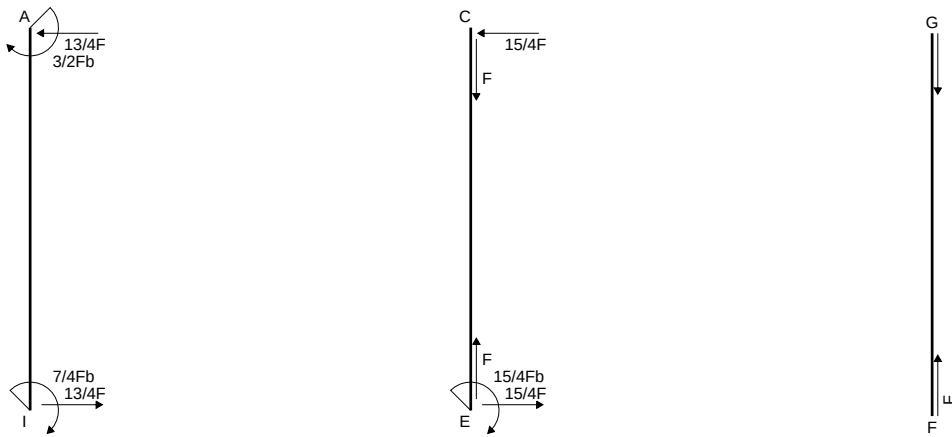
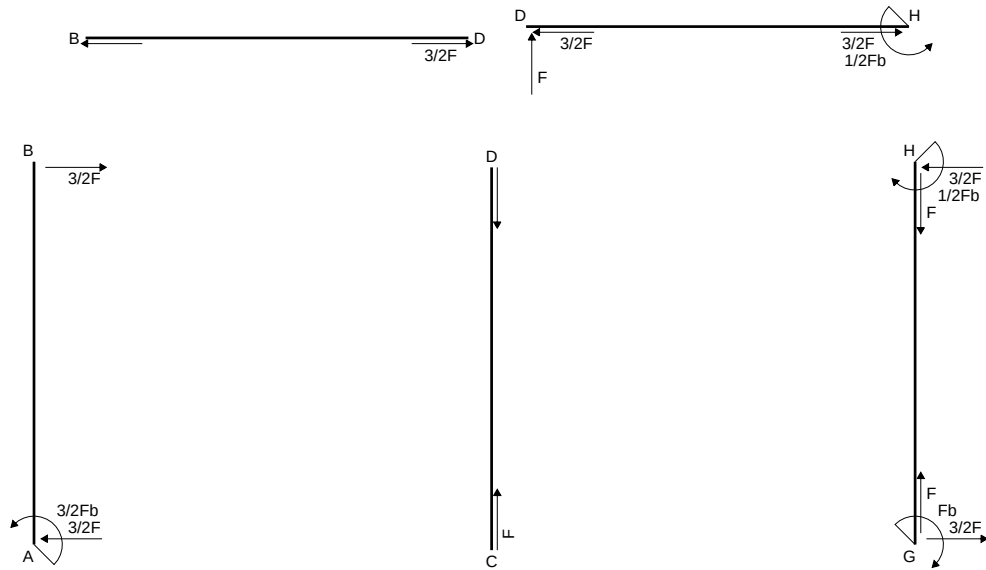
$$v_c = 15.6 \text{ mm}$$

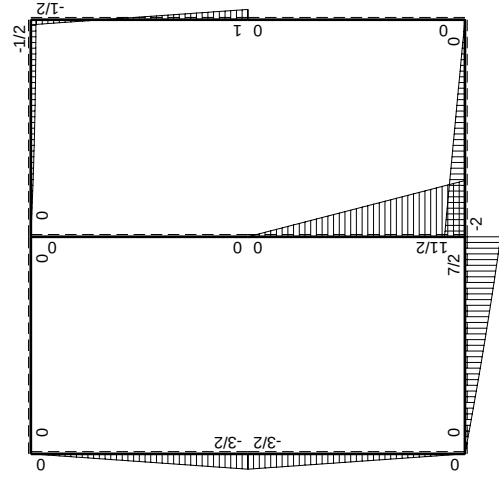
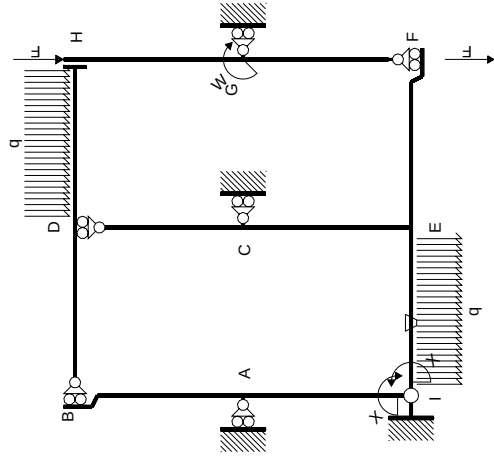
$$\sigma_c = -Mv/J_u = 108.5 \text{ N/mm}^2$$

$$\tau_c = 5.755 \text{ N/mm}^2$$

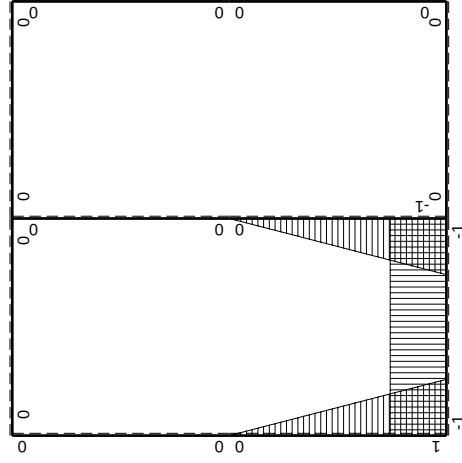
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 109. \text{ N/mm}^2$$

$$S = 6702. \text{ mm}^3$$





Schema di calcolo iperstatico



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

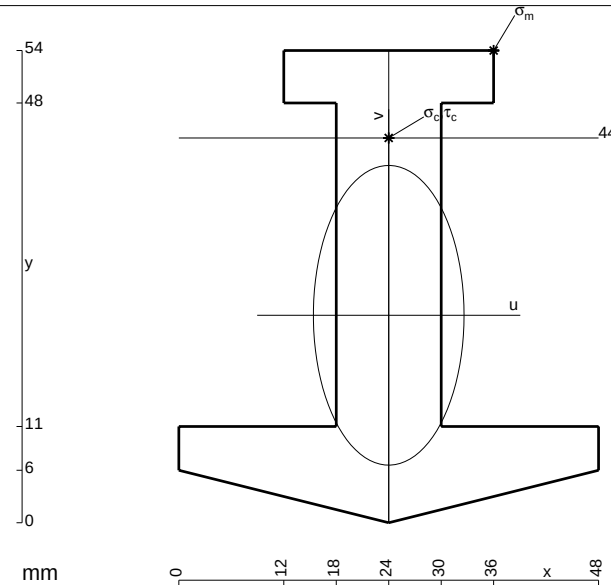
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 972. \text{ mm}^2$$

$$J_u = 285465. \text{ mm}^4$$

$$J_v = 72144. \text{ mm}^4$$

$$y_g = 23.72 \text{ mm}$$

$$T_y = 2300. \text{ N}$$

$$M_x = -1978000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.28 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

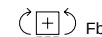
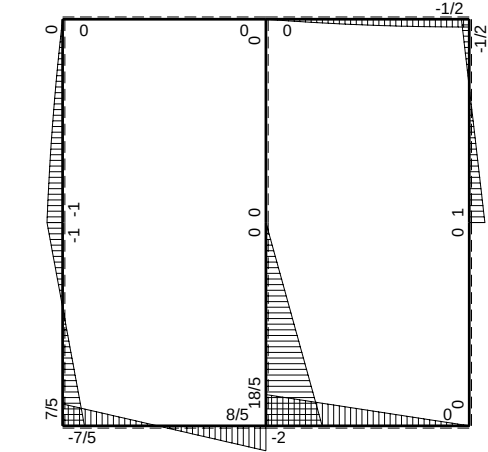
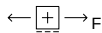
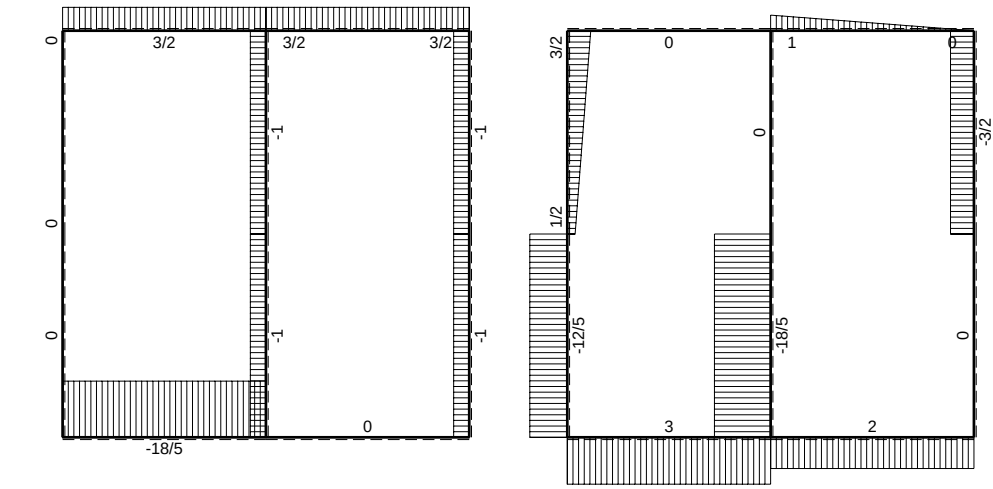
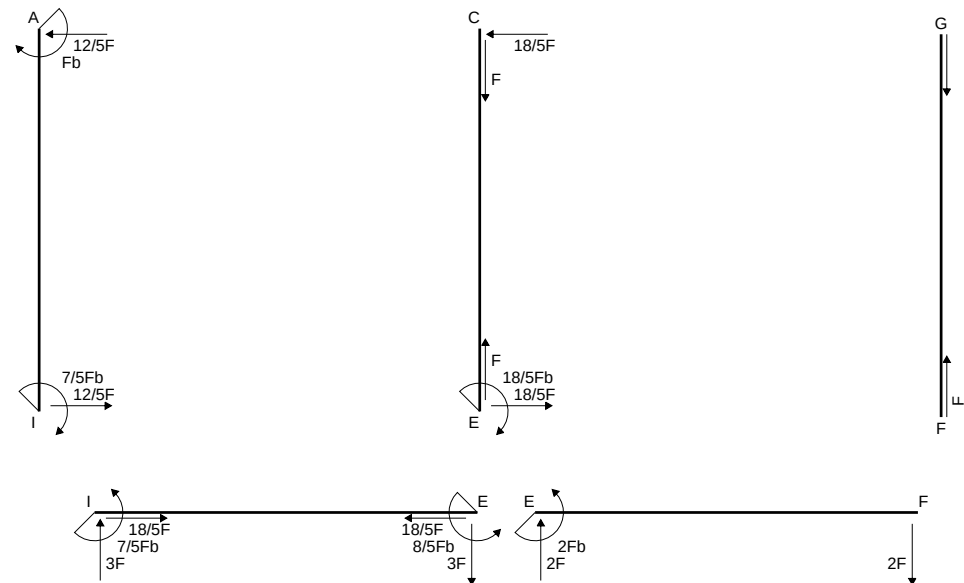
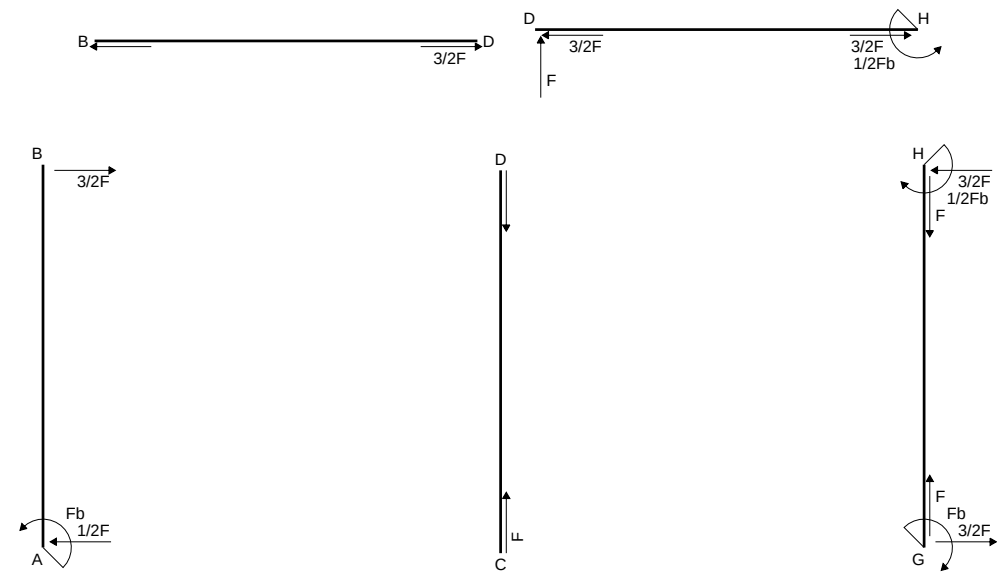
$$v_c = 20.28 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 140.5 \text{ N/mm}^2$$

$$\tau_c = 3.355 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 140.6 \text{ N/mm}^2$$

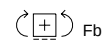
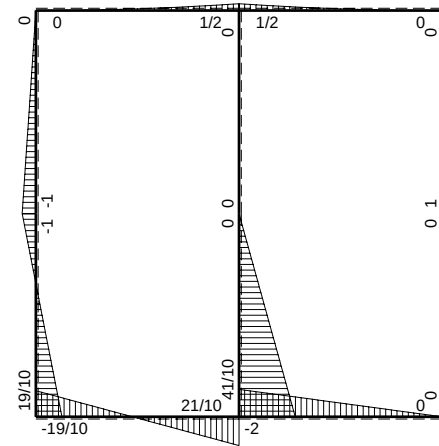
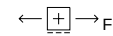
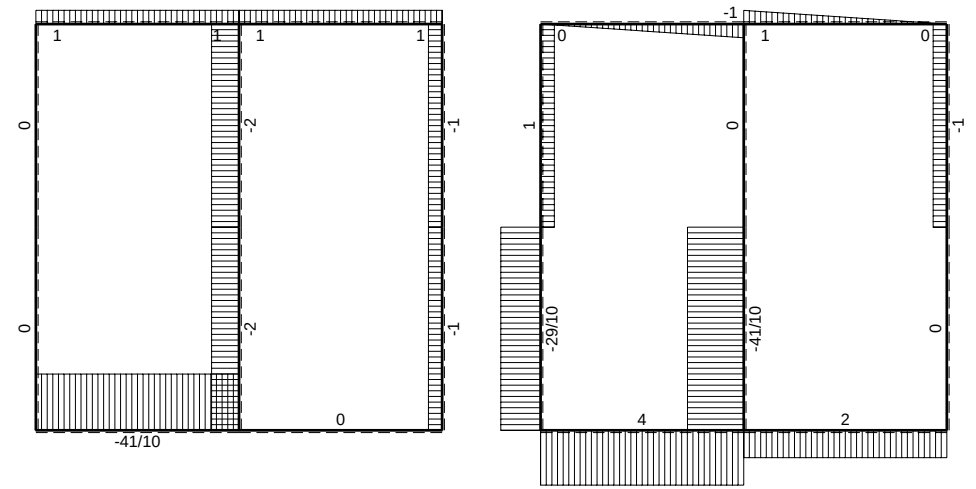
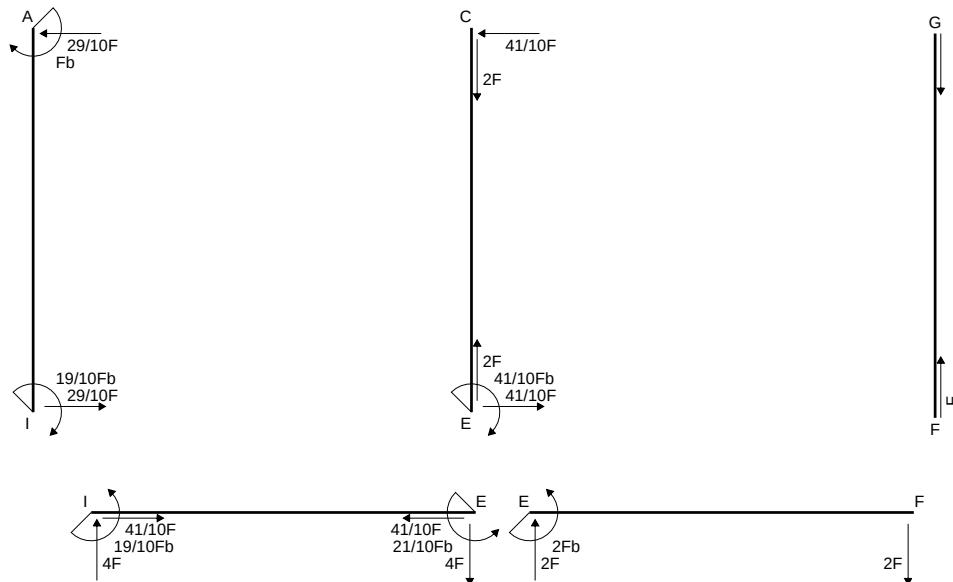
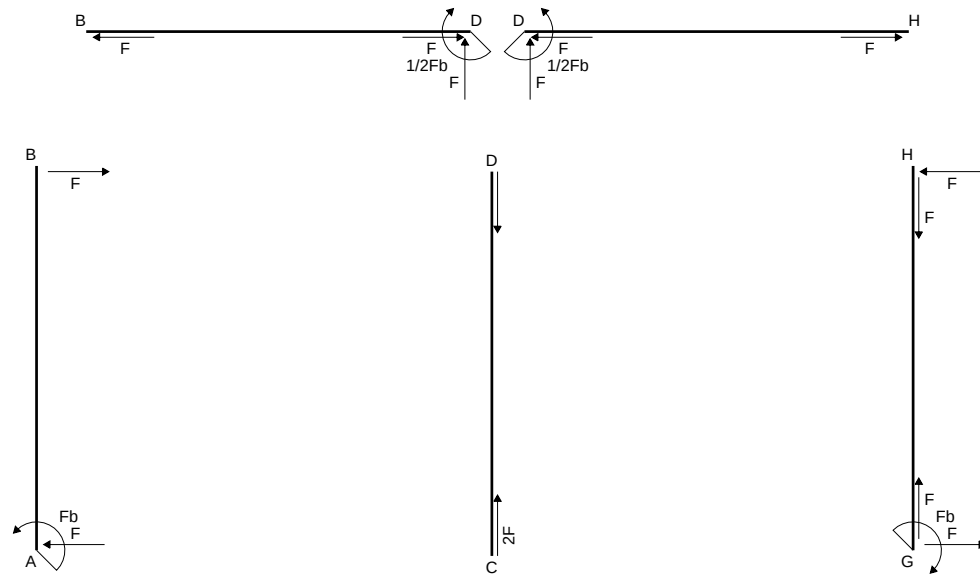
$$S = 4997. \text{ mm}^3$$

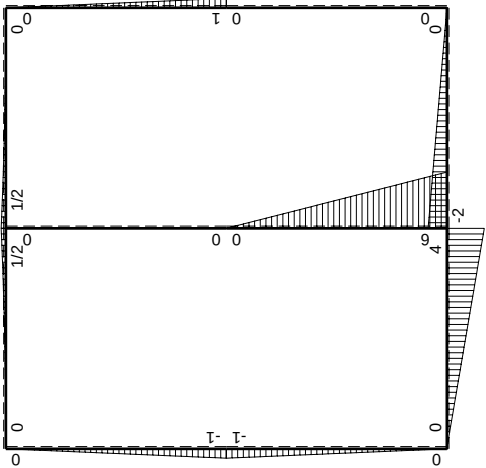
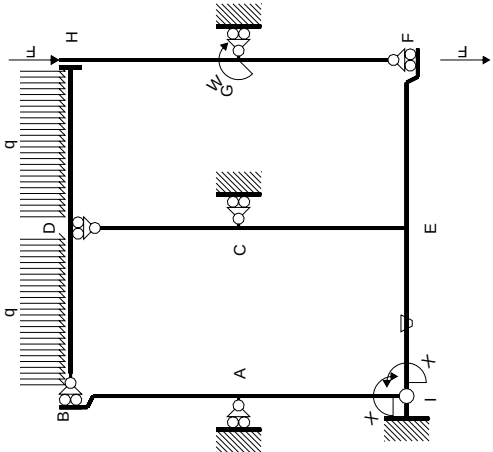


Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-Fb+1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$3/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

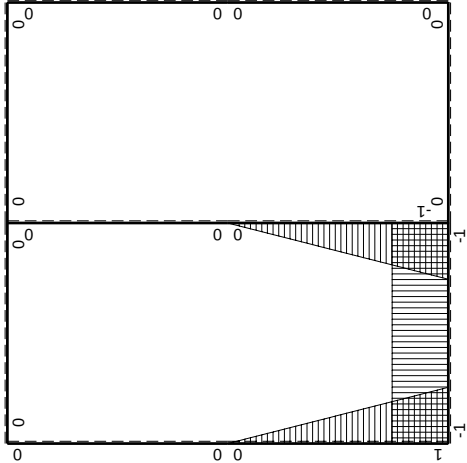
Sviluppi di calcolo iperstatica





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	4Fx	-Fb/EJ	-4Fx	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-4Fb+4Fx	Fb/EJ	-4Fb+4Fx	Fb/EJ	1		
EC b	$-1+x/b$	6Fb-6Fx	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	-6Fx	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-19/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

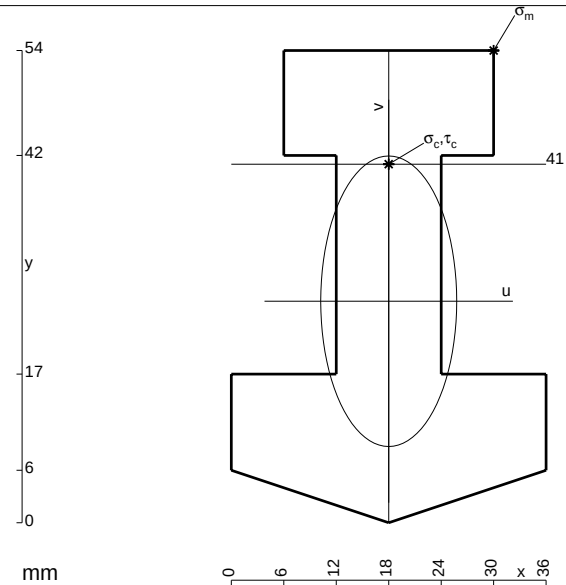
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1092. \text{ mm}^2$$

$$J_u = 301397. \text{ mm}^4$$

$$J_v = 66024. \text{ mm}^4$$

$$y_g = 25.33 \text{ mm}$$

$$T_y = 2480. \text{ N}$$

$$M_x = -2405600. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.67 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 228.8 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

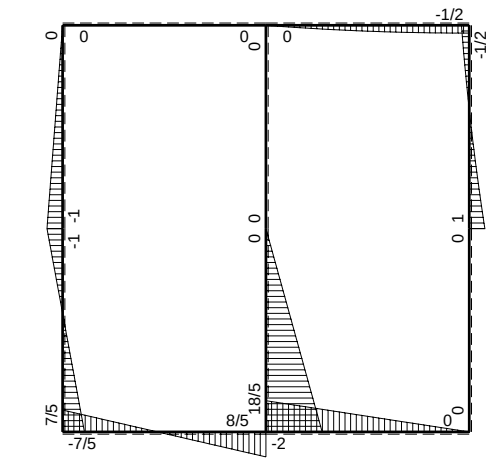
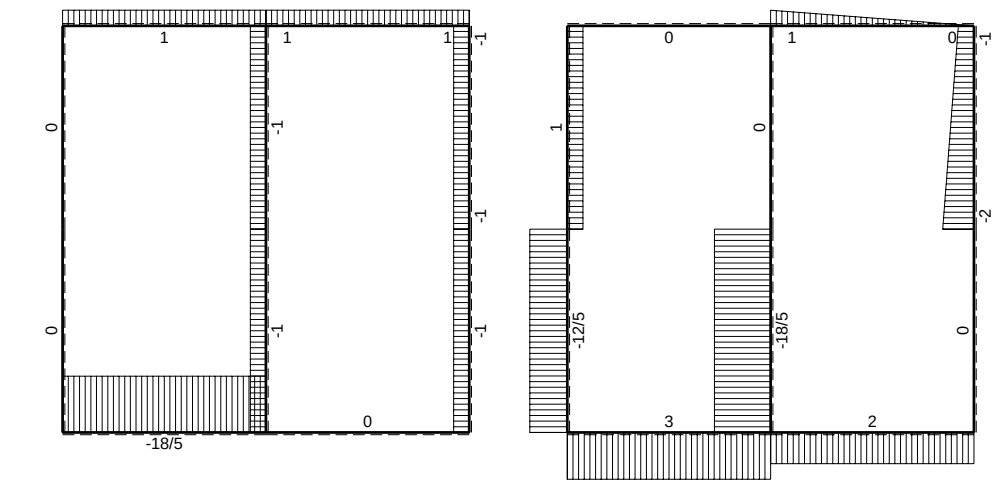
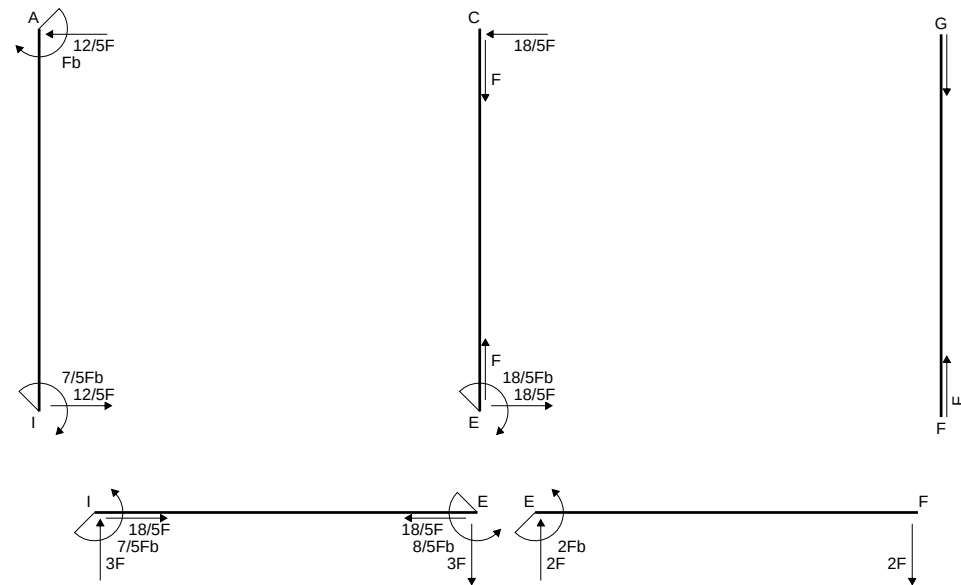
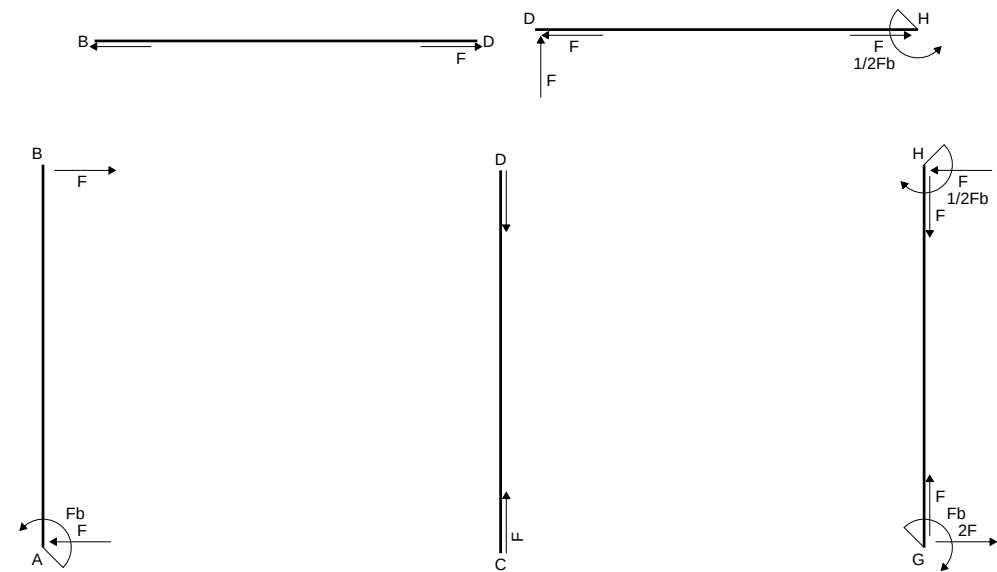
$$v_c = 15.67 \text{ mm}$$

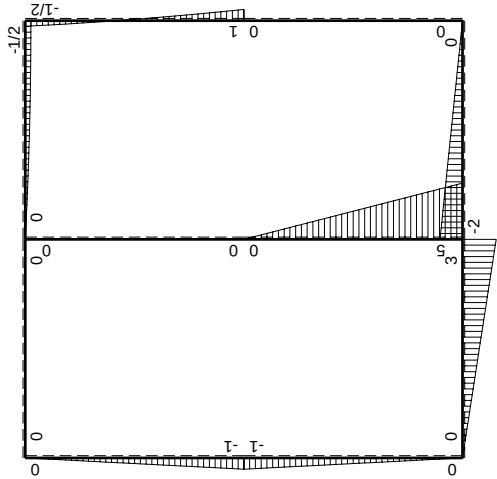
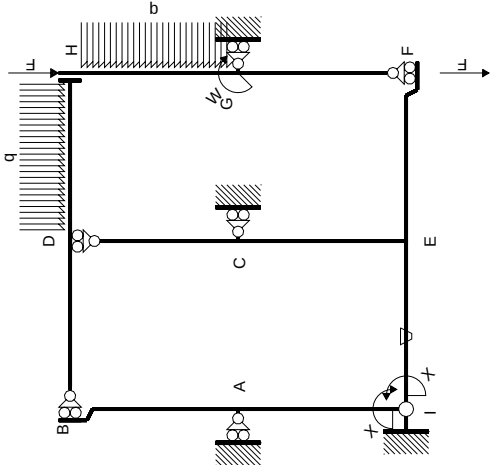
$$\sigma_c = -Mv/J_u = 125.1 \text{ N/mm}^2$$

$$\tau_c = 4.61 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 125.3 \text{ N/mm}^2$$

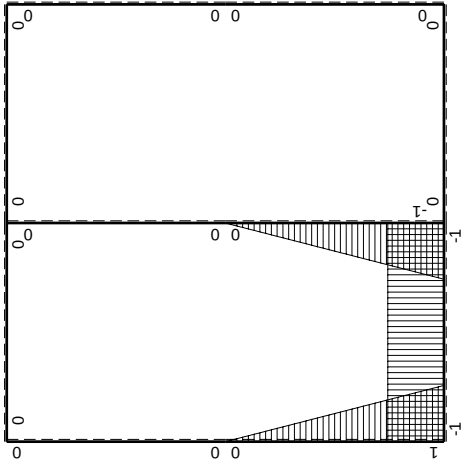
$$S = 6723. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_0 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x (M_o/EJ + \theta) dx$	$\int X M_x M_x / EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

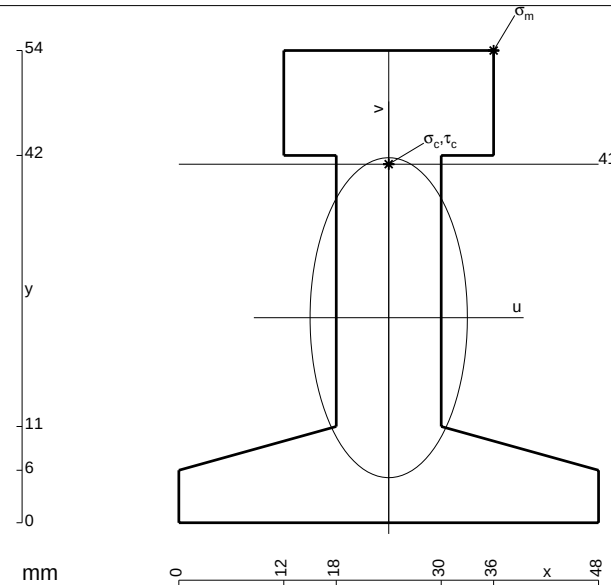
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1098. \text{ mm}^2$$

$$J_u = 367673. \text{ mm}^4$$

$$J_v = 88884. \text{ mm}^4$$

$$y_g = 23.45 \text{ mm}$$

$$T_y = 2820. \text{ N}$$

$$M_x = -2876400. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.55 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

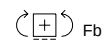
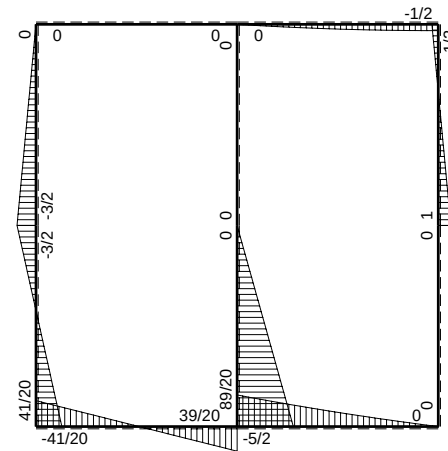
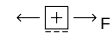
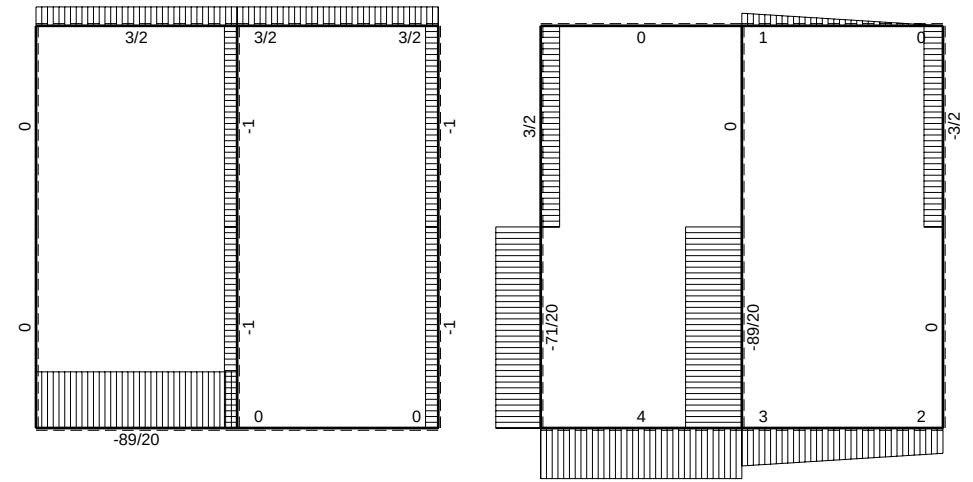
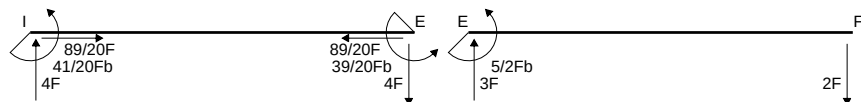
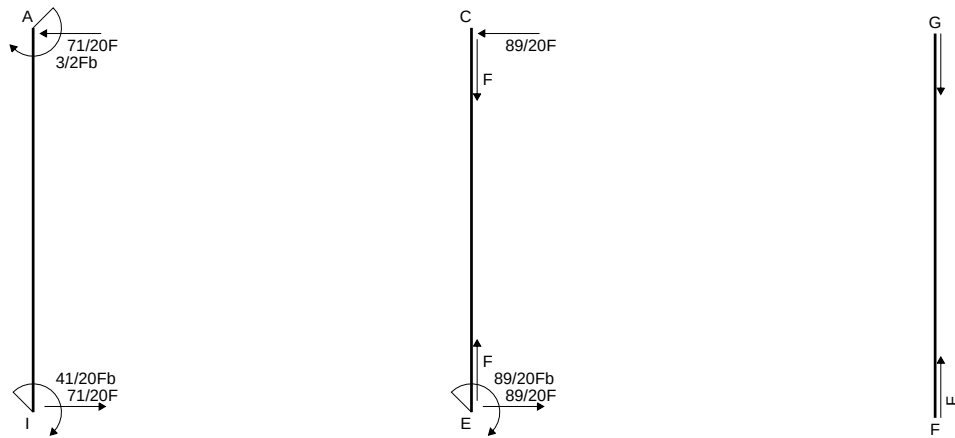
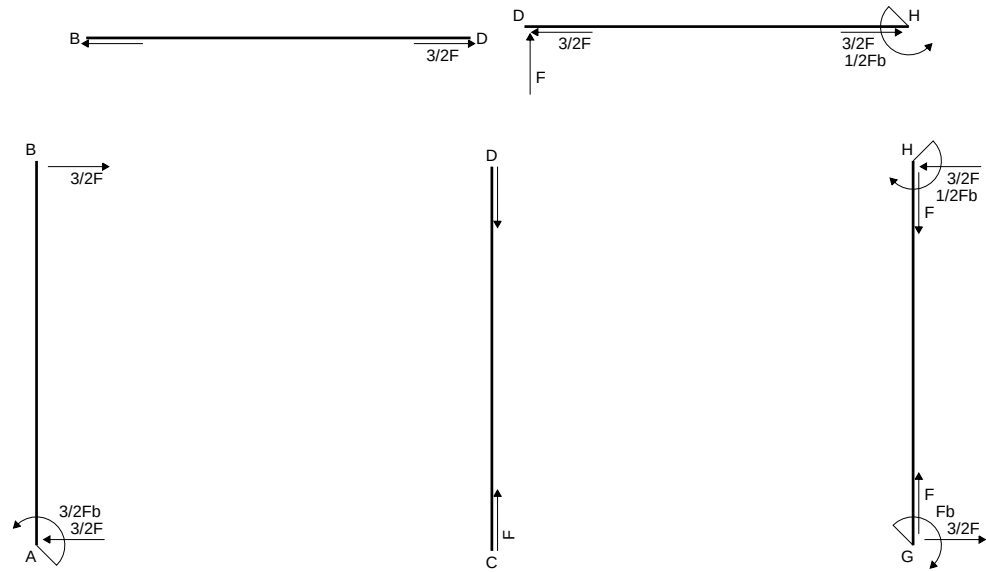
$$v_c = 17.55 \text{ mm}$$

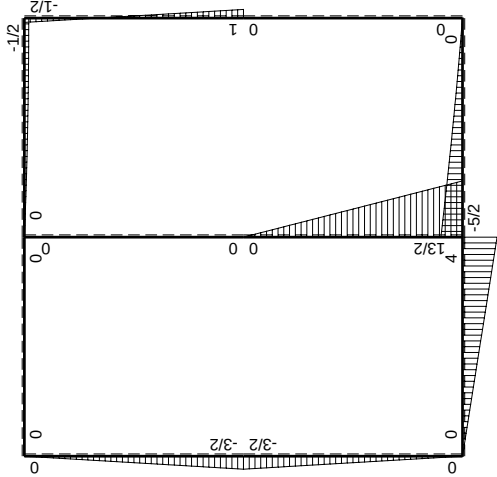
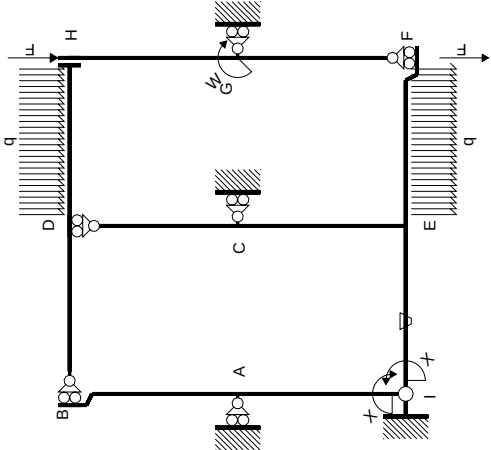
$$\sigma_c = -Mv/J_u = 137.3 \text{ N/mm}^2$$

$$\tau_c = 4.658 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 137.6 \text{ N/mm}^2$$

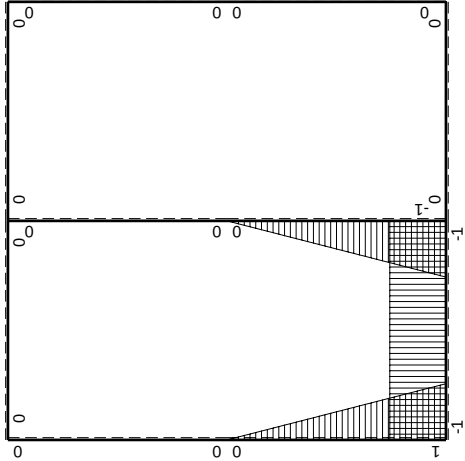
$$S = 7288. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-41/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$41/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

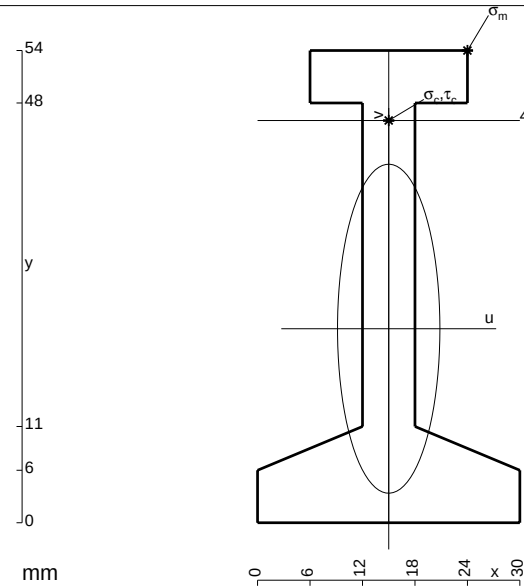
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 600. \text{ mm}^2$$

$$J_u = 212405. \text{ mm}^4$$

$$J_v = 20592. \text{ mm}^4$$

$$y_g = 22.19 \text{ mm}$$

$$T_y = 2940. \text{ N}$$

$$M_x = -1323000. \text{ Nmm}$$

$$x_m = 24. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 31.81 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 198.2 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

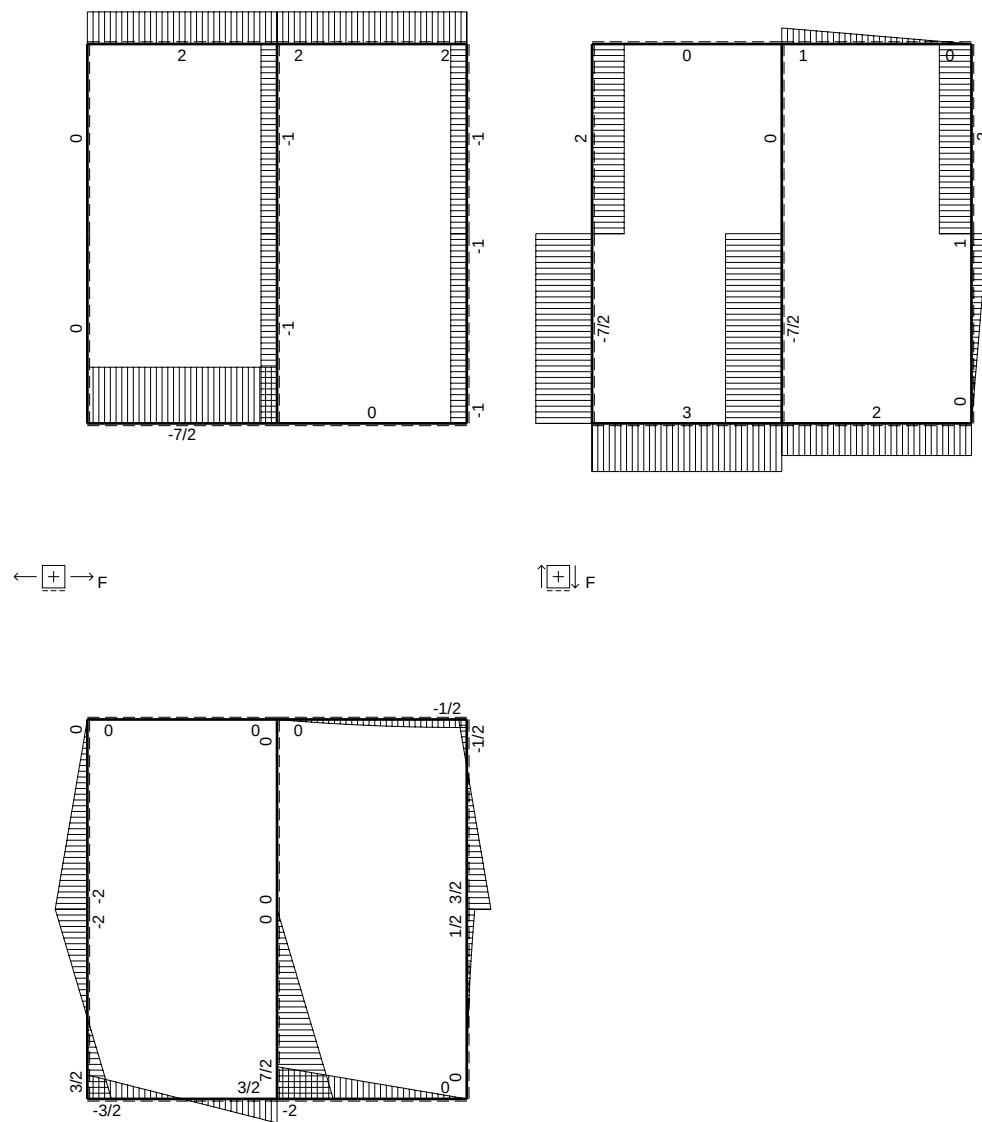
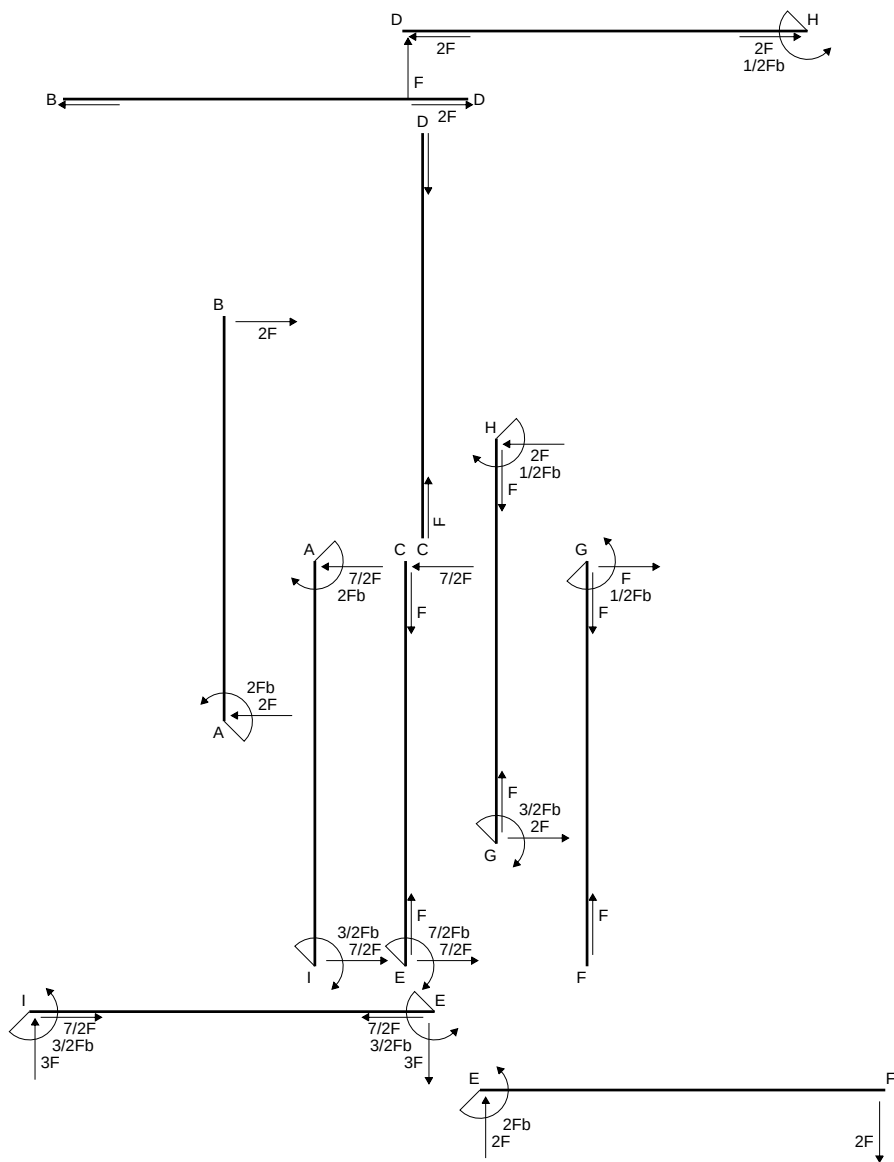
$$v_c = 23.81 \text{ mm}$$

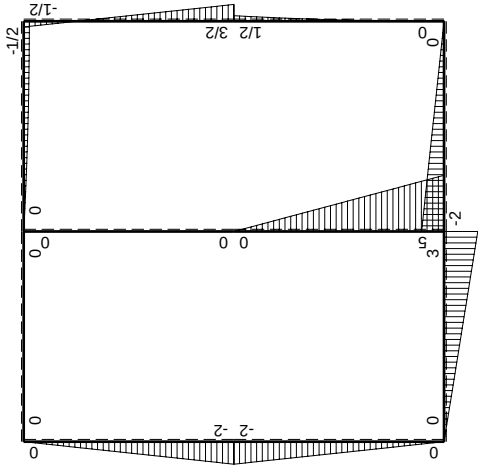
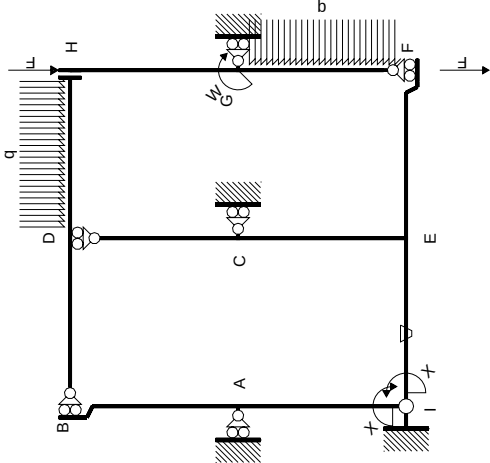
$$\sigma_c = -Mv/J_u = 148.3 \text{ N/mm}^2$$

$$\tau_c = 7.866 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 148.9 \text{ N/mm}^2$$

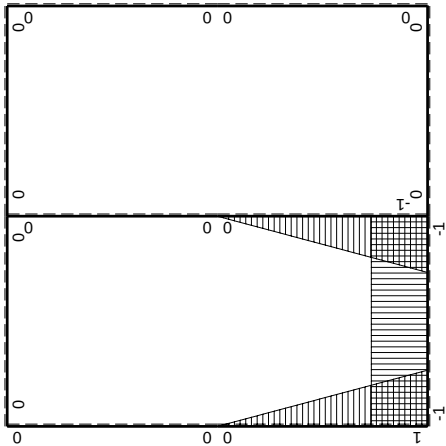
$$S = 3410. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
BA b	0	$2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-2Fx$	0	$-2Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$2Fb-2Fx$	0	$-2Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

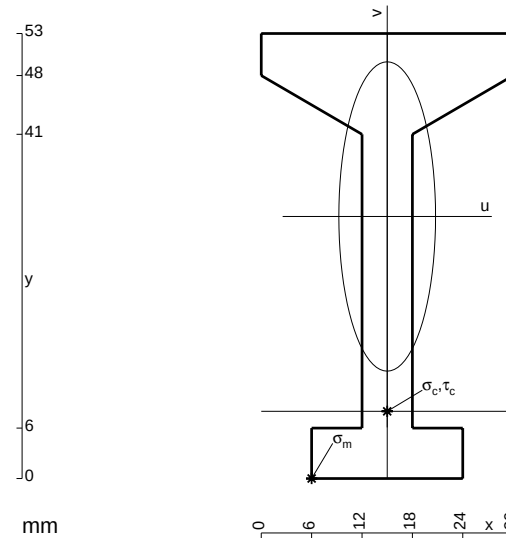
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-2x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[-x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-b + 2/3 b) Fb \frac{1}{EJ} = -1/3 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-2x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[-x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-b + 2/3 b) Fb \frac{1}{EJ} = -1/3 Fb^2/EJ$$



$$A = 594. \text{ mm}^2$$

$$J_u = 201694. \text{ mm}^4$$

$$J_v = 19710. \text{ mm}^4$$

$$y_g = 31.21 \text{ mm}$$

$$T_y = 2320. \text{ N}$$

$$M_x = -1345600. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -31.21 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.2 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 8. \text{ mm}$$

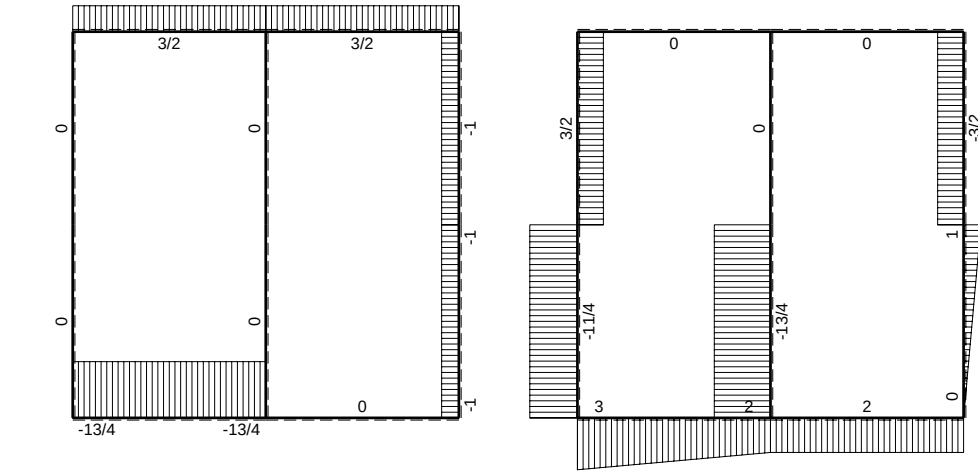
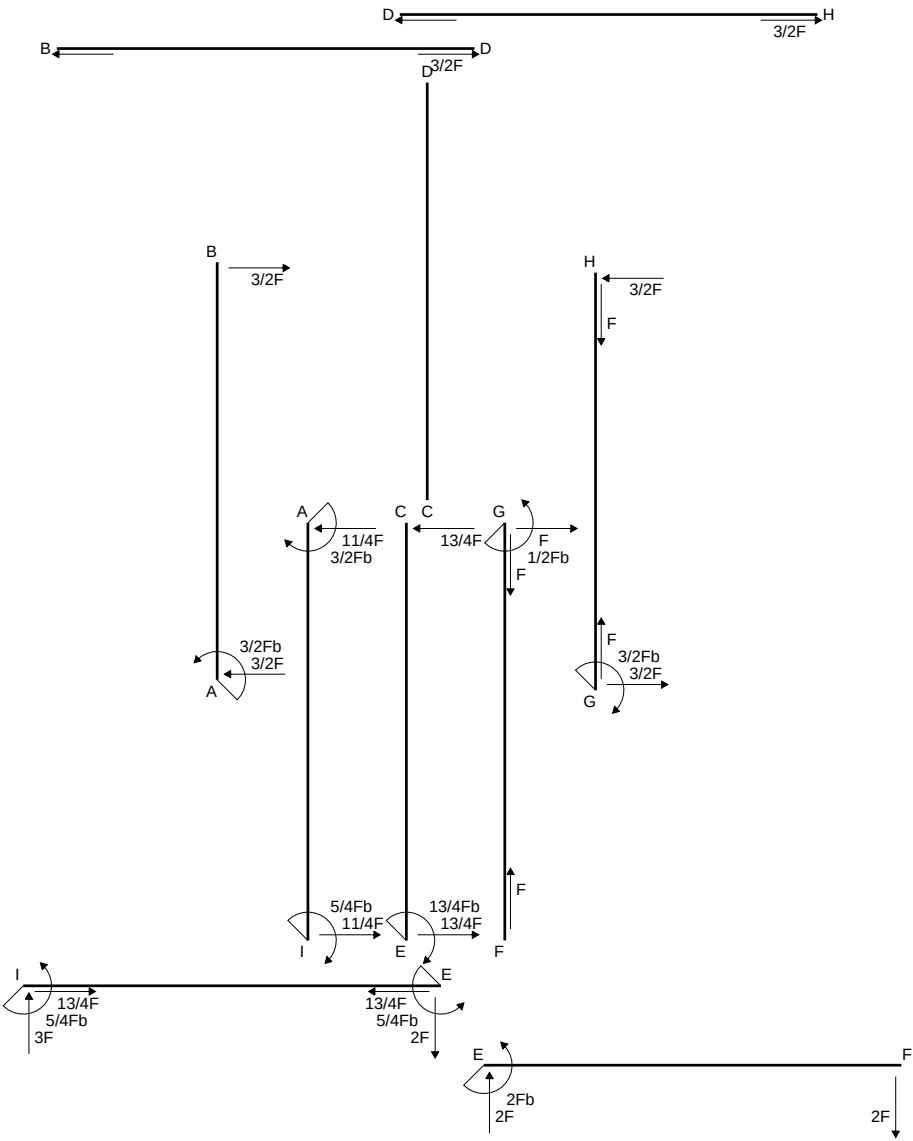
$$v_c = -23.21 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -154.8 \text{ N/mm}^2$$

$$\tau_c = 6.398 \text{ N/mm}^2$$

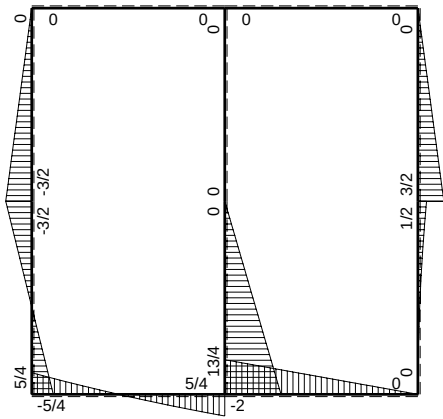
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 155.2 \text{ N/mm}^2$$

$$S = 3337. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

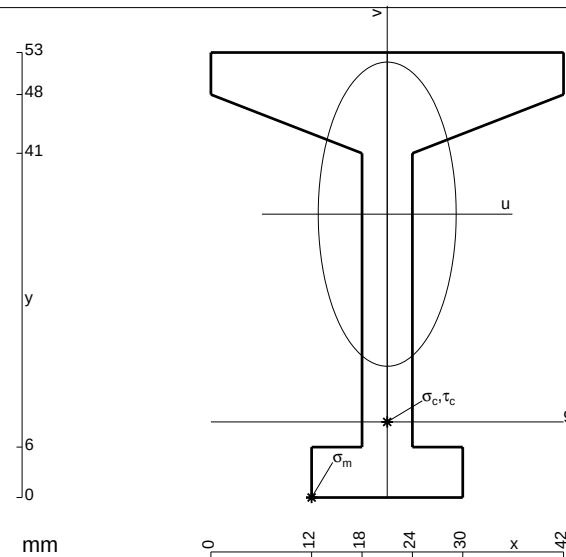
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 696. \text{ mm}^2$$

$$J_u = 228562. \text{ mm}^4$$

$$J_v = 47016. \text{ mm}^4$$

$$y_g = 33.75 \text{ mm}$$

$$T_y = 2360. \text{ N}$$

$$M_x = -1486800. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.75 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

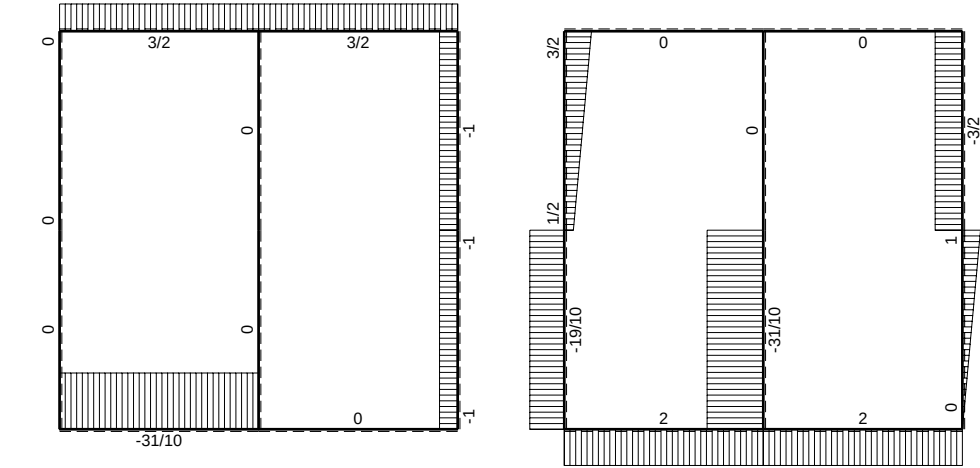
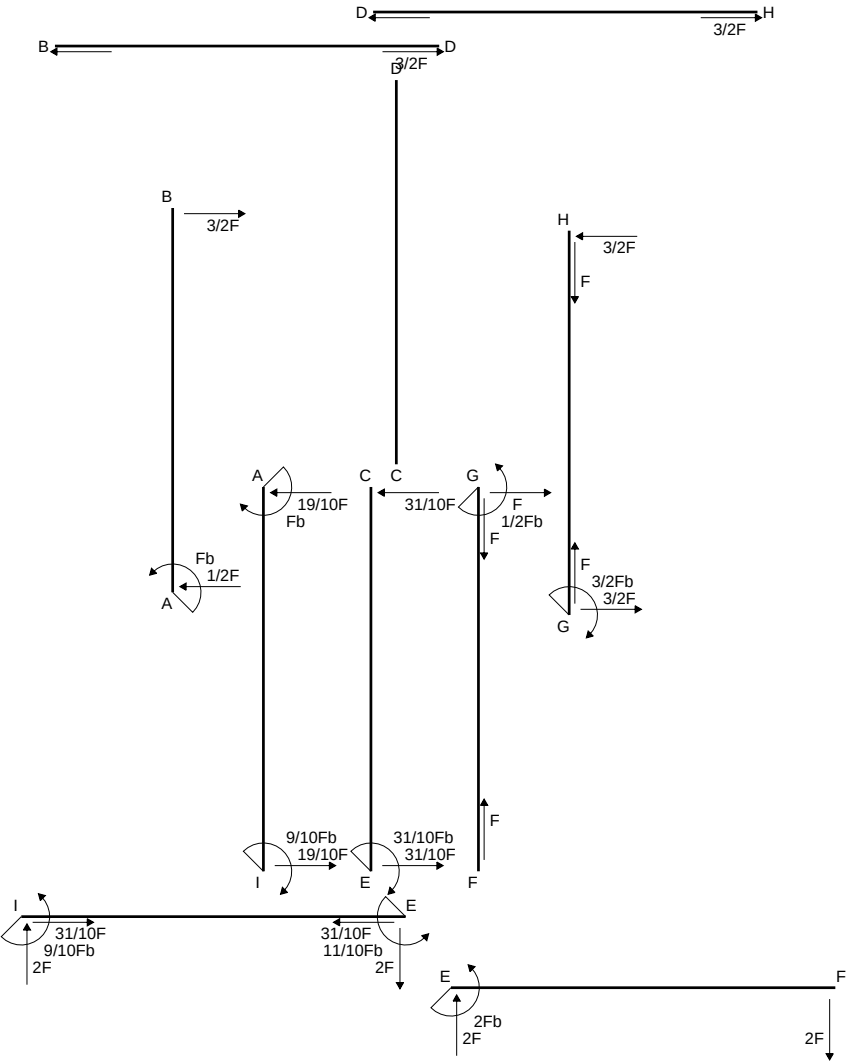
$$v_c = -24.75 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -161. \text{ N/mm}^2$$

$$\tau_c = 6.527 \text{ N/mm}^2$$

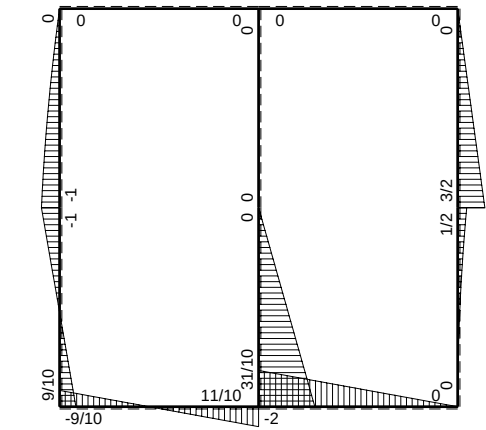
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 161.4 \text{ N/mm}^2$$

$$S = 3793. \text{ mm}^3$$

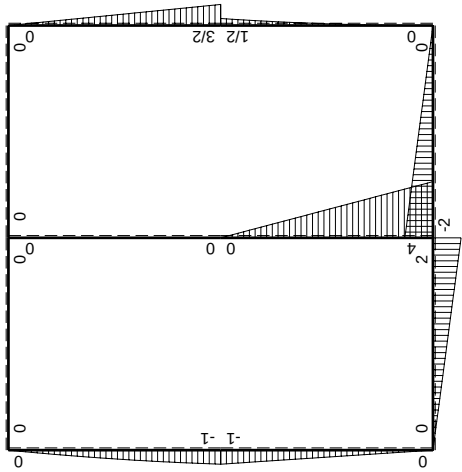
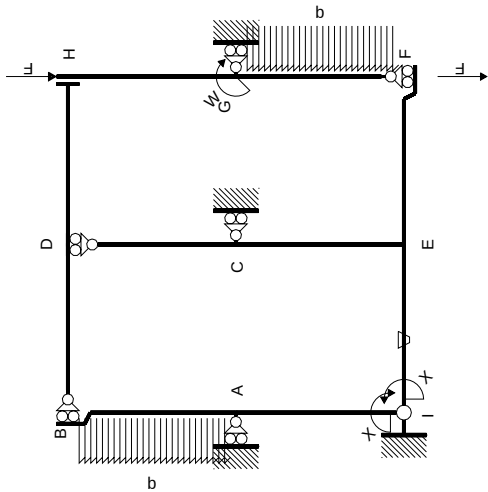


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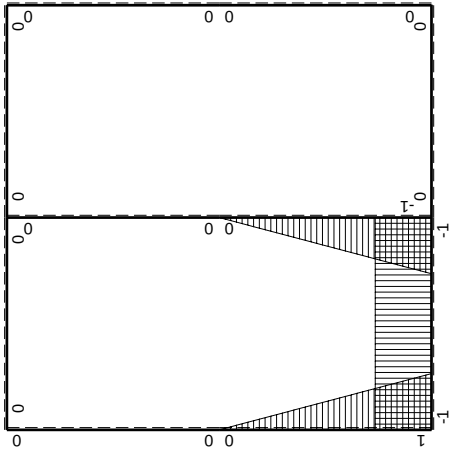


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-Fb+1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$3/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

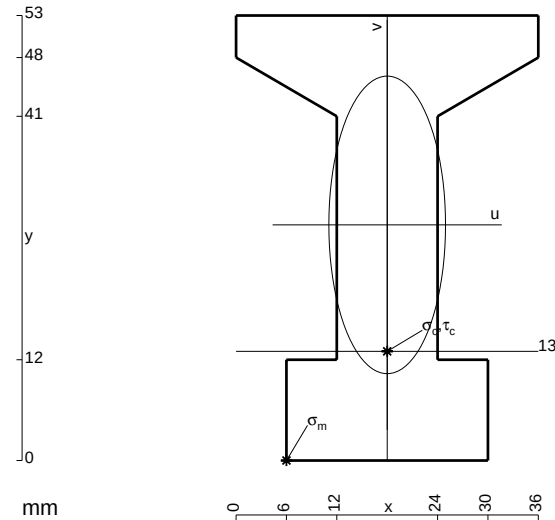
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 984. \text{ mm}^2$$

$$J_u = 309174. \text{ mm}^4$$

$$J_v = 47520. \text{ mm}^4$$

$$y_g = 28.06 \text{ mm}$$

$$T_y = 3720. \text{ N}$$

$$M_x = -2529600. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.06 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

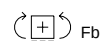
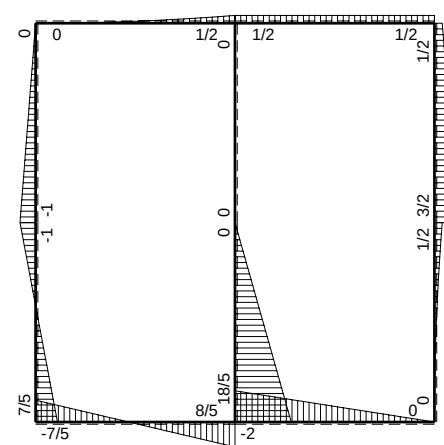
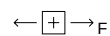
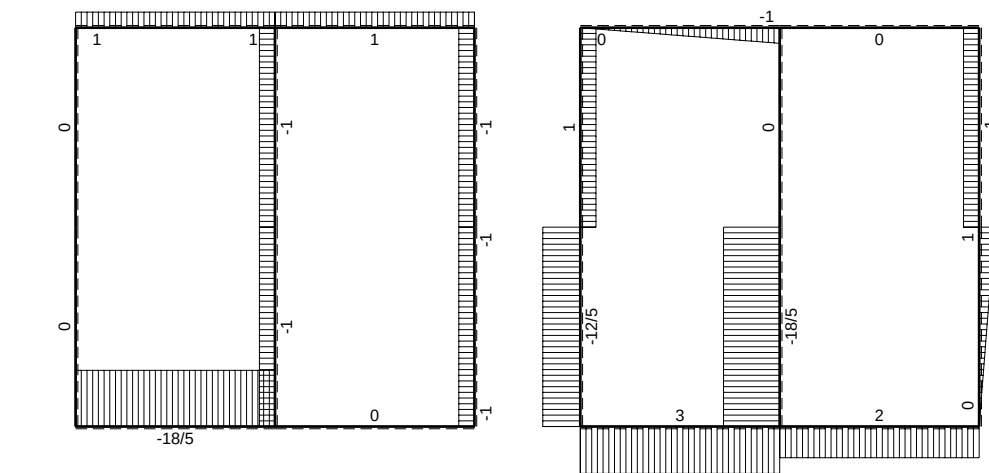
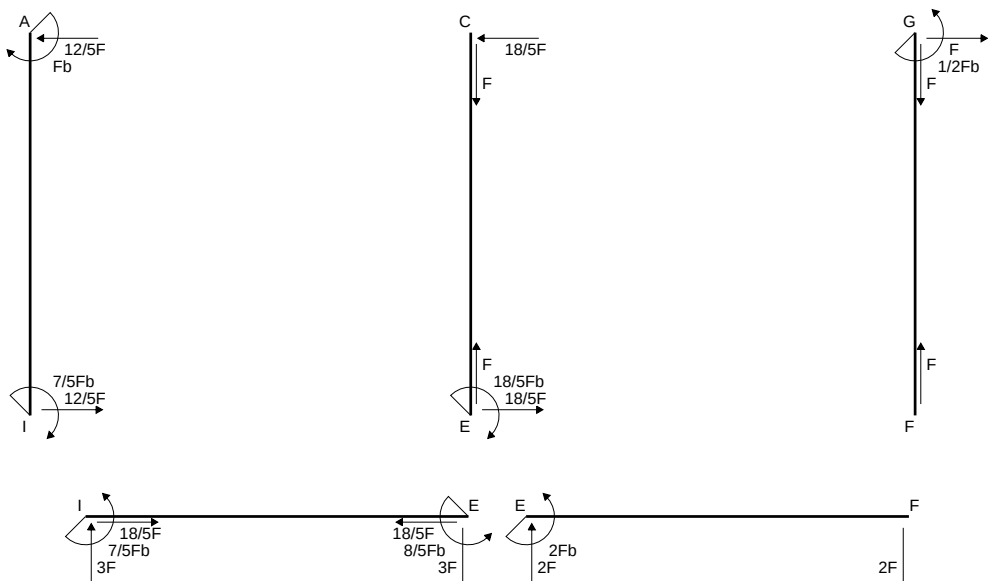
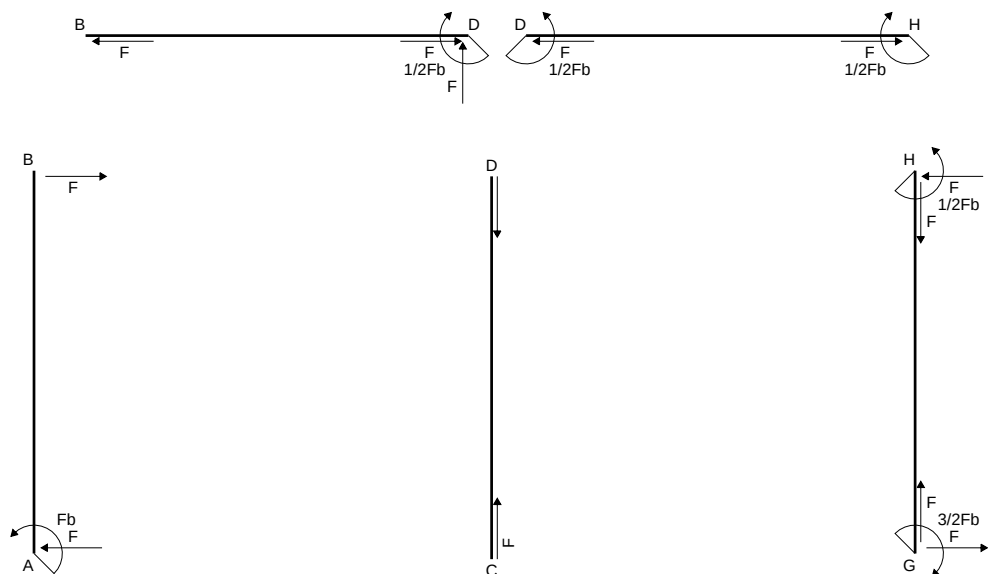
$$v_c = -15.06 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -123.2 \text{ N/mm}^2$$

$$\tau_c = 6.558 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 123.8 \text{ N/mm}^2$$

$$S = 6541. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

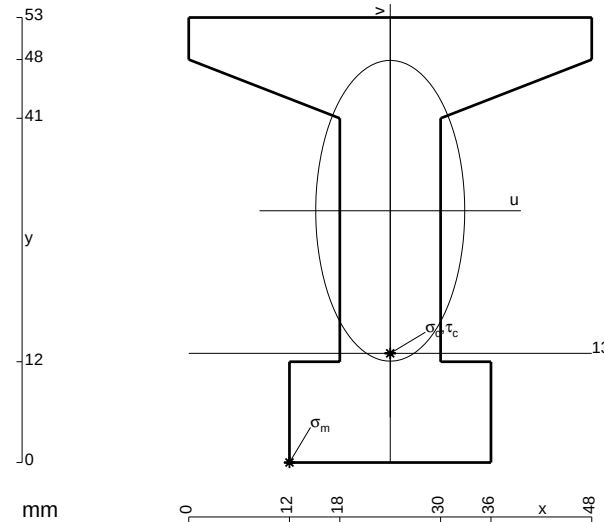
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1086. \text{ mm}^2$$

$$J_u = 348629. \text{ mm}^4$$

$$J_v = 85500. \text{ mm}^4$$

$$y_g = 29.98 \text{ mm}$$

$$T_y = 3760. \text{ N}$$

$$M_x = -2782400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.98 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.3 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

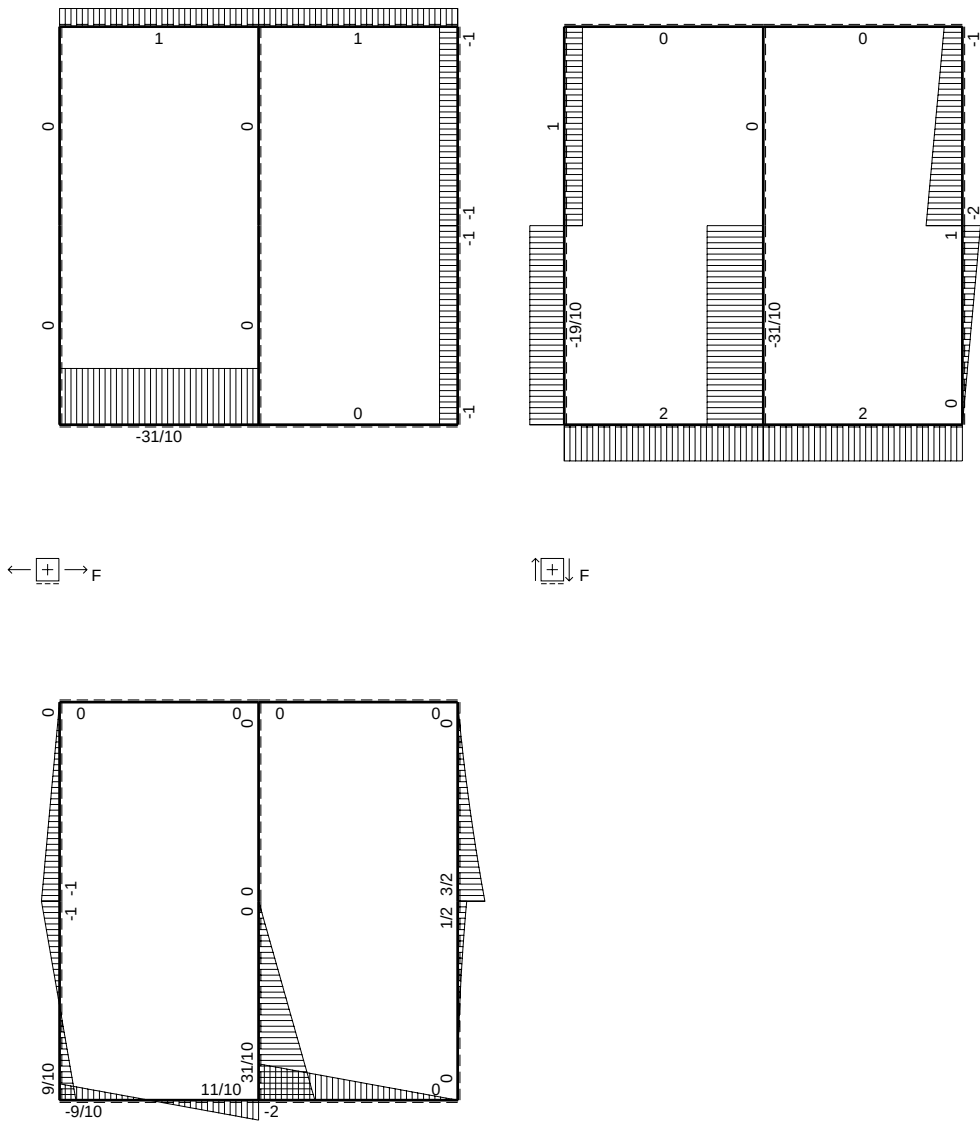
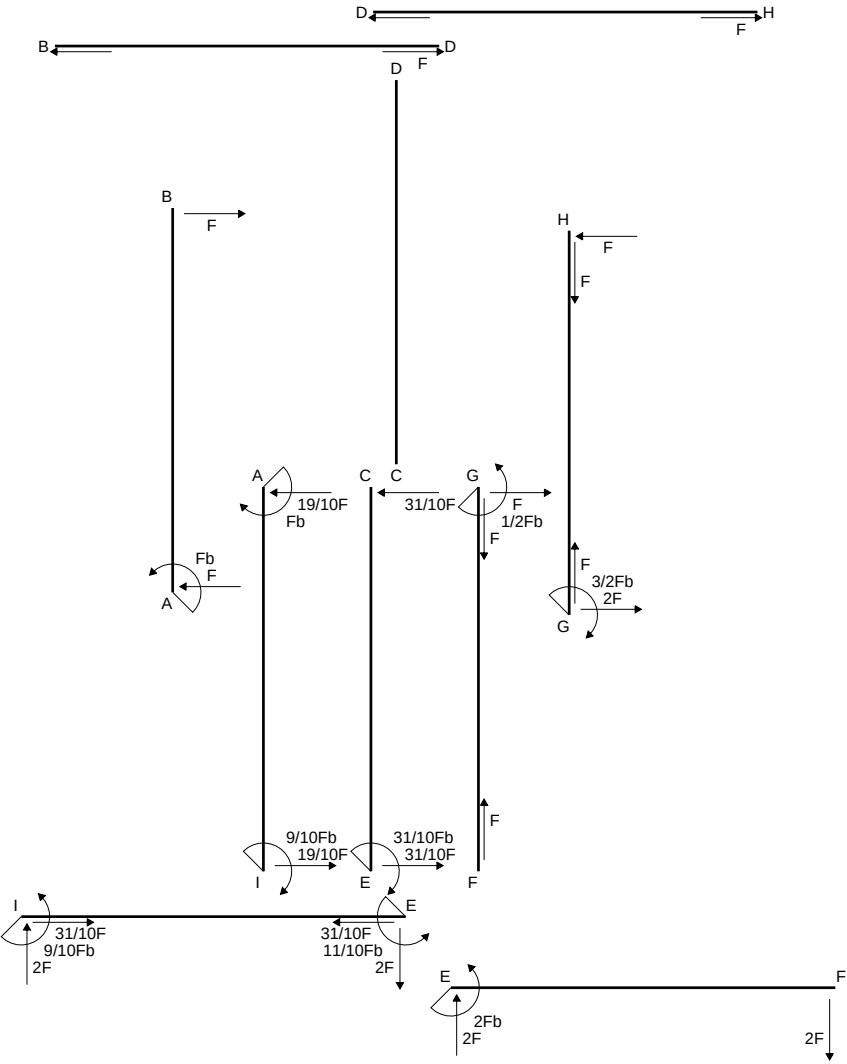
$$v_c = -16.98 \text{ mm}$$

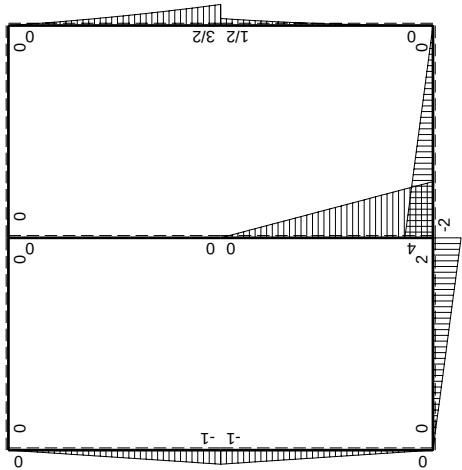
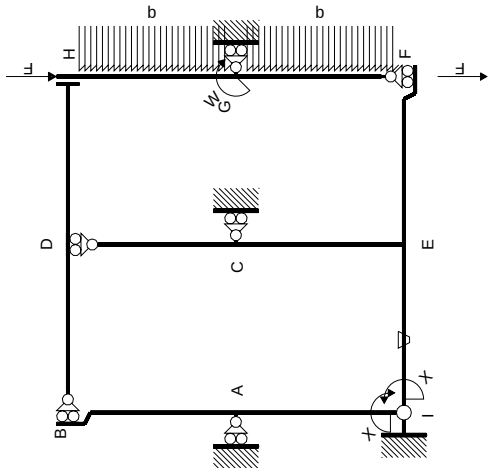
$$\sigma_c = -Mv/J_u = -135.5 \text{ N/mm}^2$$

$$\tau_c = 6.397 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 136. \text{ N/mm}^2$$

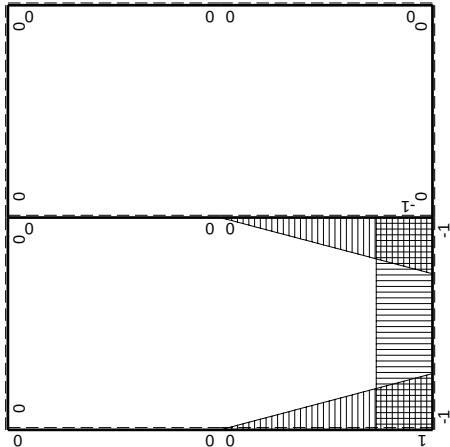
$$S^* = 7117. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	2Fx	-Fb/EJ	-2Fx	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	-2Fb+2Fx	Fb/EJ	-2Fb+2Fx	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

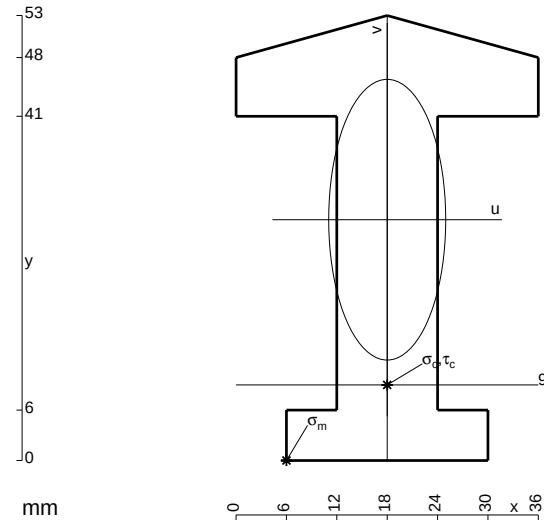
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 906. \text{ mm}^2$$

$$J_u = 253401. \text{ mm}^4$$

$$J_v = 44028. \text{ mm}^4$$

$$y_g = 28.68 \text{ mm}$$

$$T_y = 2220. \text{ N}$$

$$M_x = -1753800. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.68 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -198.5 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

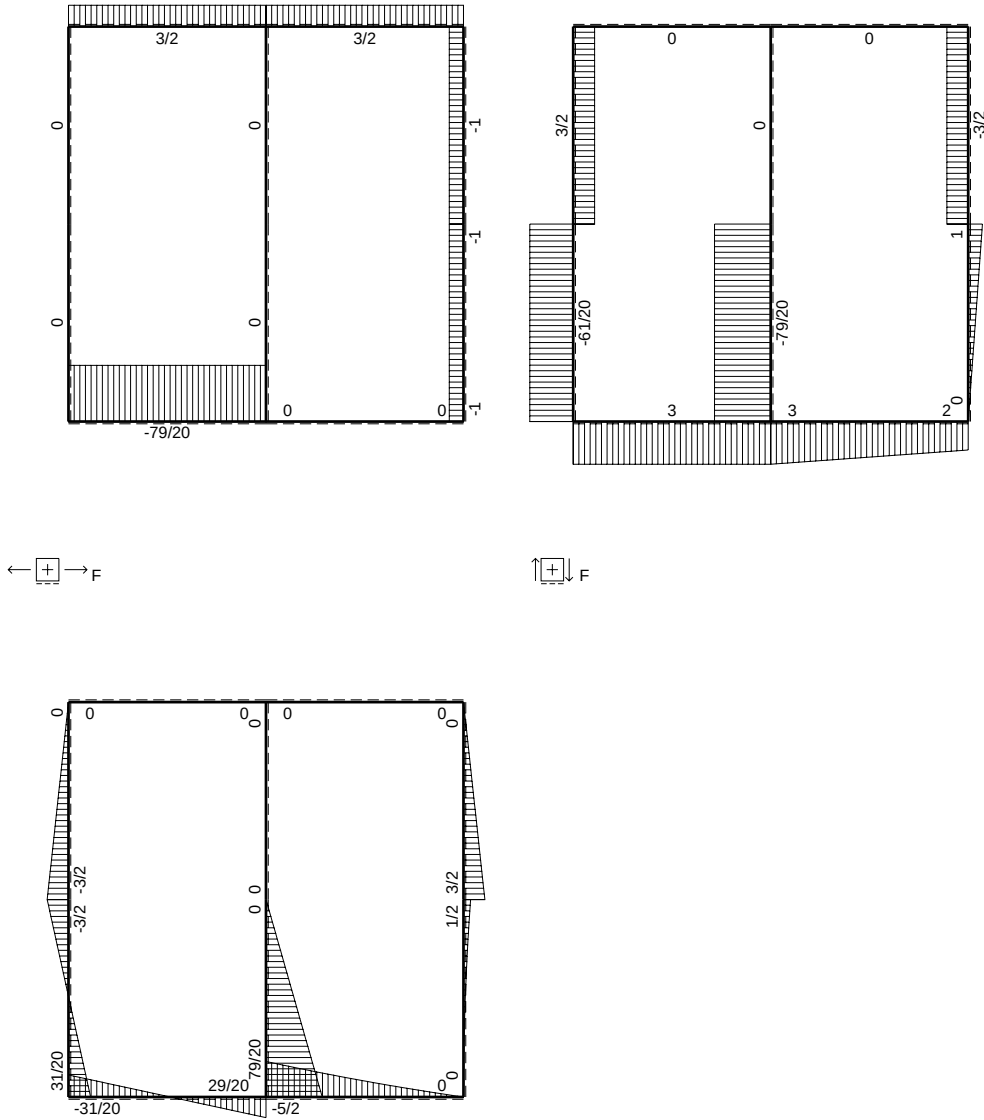
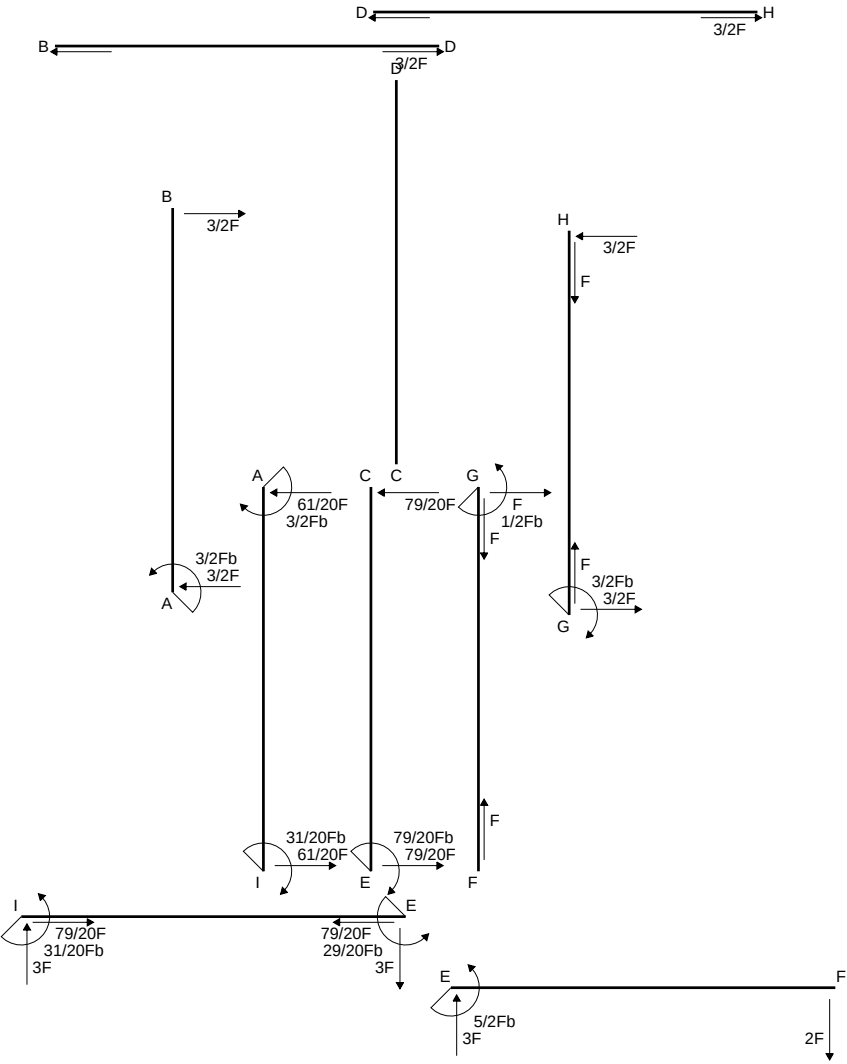
$$v_c = -19.68 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -136.2 \text{ N/mm}^2$$

$$\tau_c = 3.257 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 136.3 \text{ N/mm}^2$$

$$S = 4461. \text{ mm}^3$$



$\left[\begin{array}{c} + \\ \curvearrowright \end{array} \right] F_b$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

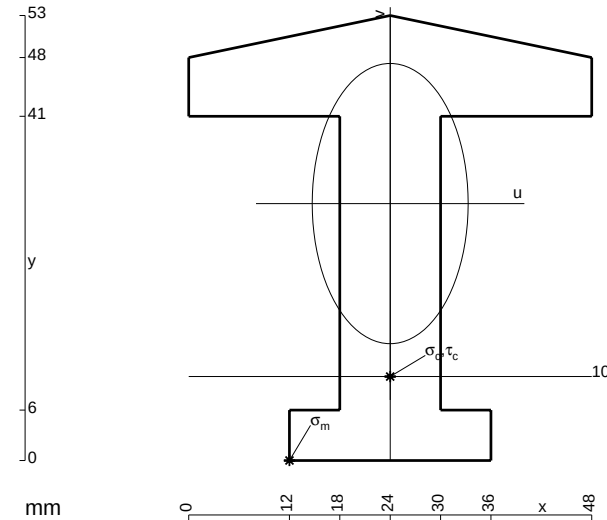
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

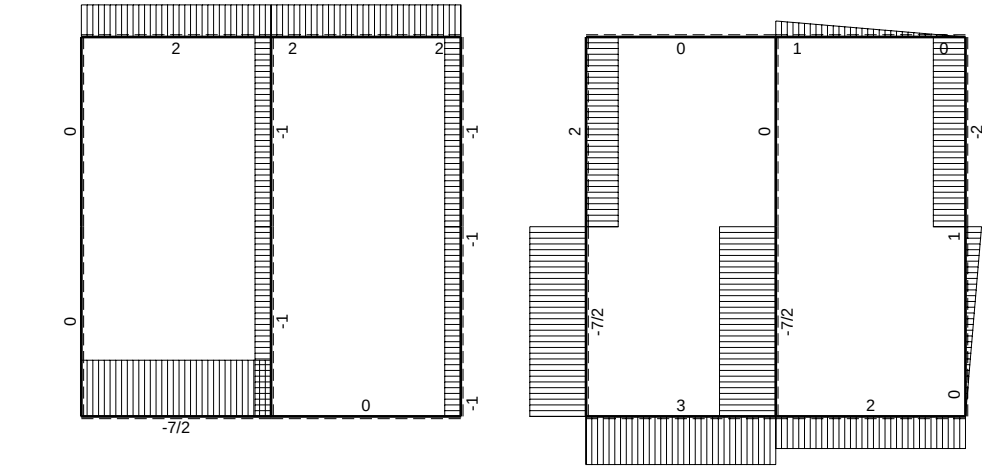
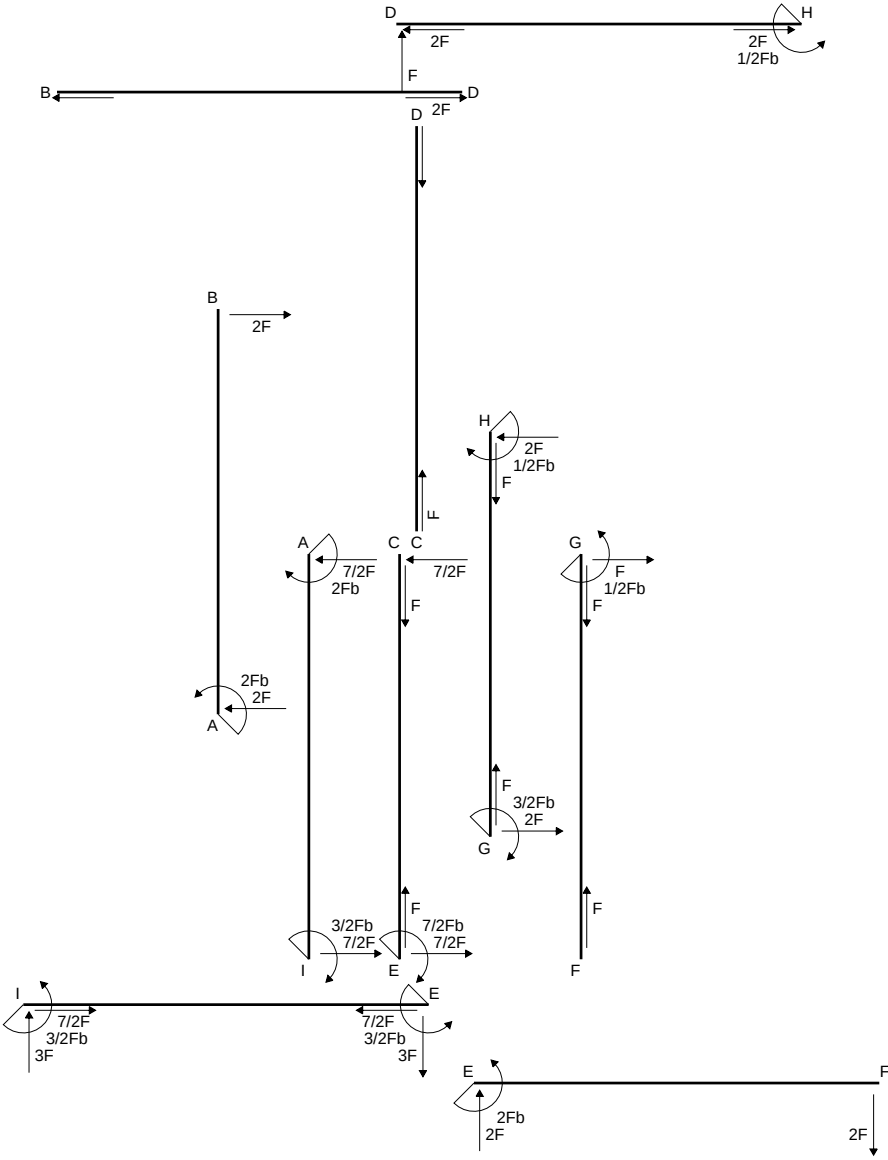
$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

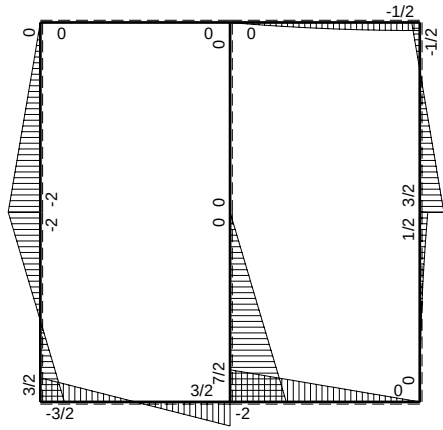


$$\begin{aligned} A &= 1020. \text{ mm}^2 \\ J_u &= 284254. \text{ mm}^4 \\ J_v &= 87984. \text{ mm}^4 \\ y_g &= 30.6 \text{ mm} \\ T_y &= 2760. \text{ N} \\ M_x &= -1932000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.6 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -20.6 \text{ mm} \\ \sigma_c &= -Mv/J_u = -140. \text{ N/mm}^2 \\ \tau_c &= 4.094 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 140.2 \text{ N/mm}^2 \\ S &= 5060. \text{ mm}^3 \end{aligned}$$

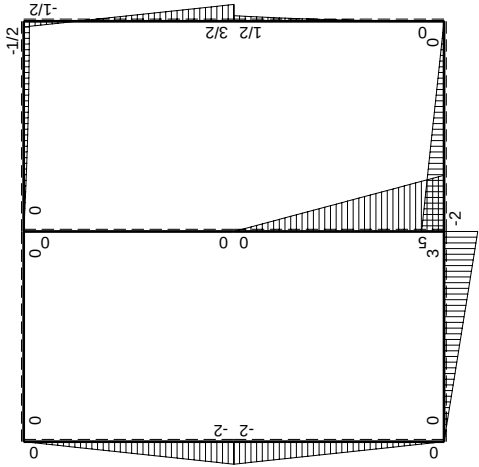
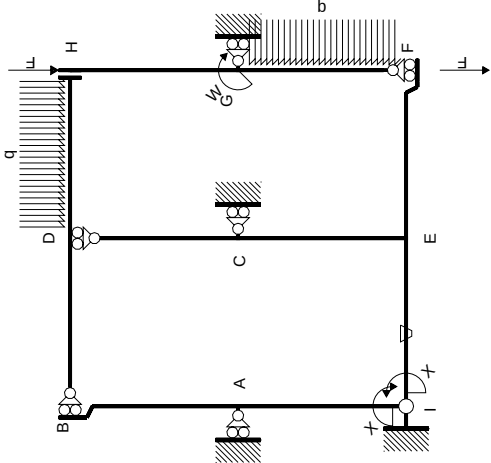


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

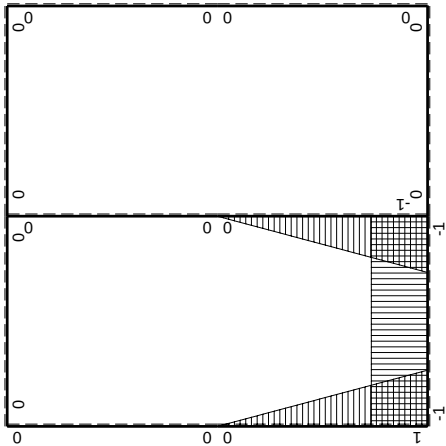


↺ $\boxed{+}$ ↻ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
BA b	0	$2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-2Fx$	0	$-2Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$2Fb-2Fx$	0	$-2Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

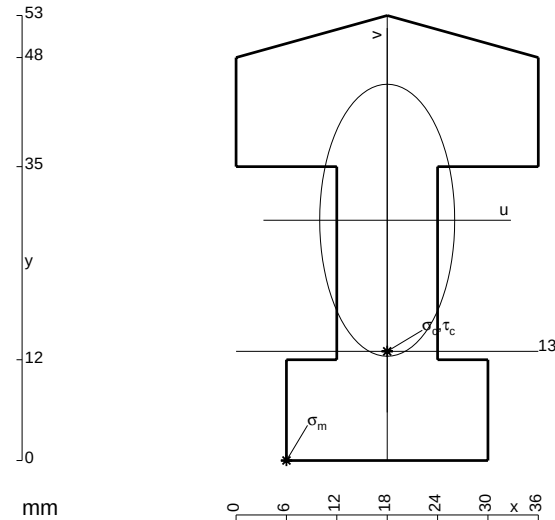
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[-x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-b + 2/3 b) Fb \frac{1}{EJ} = -1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[-x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-b + 2/3 b) Fb \frac{1}{EJ} = -1/3 Fb^2/EJ$$



$$A = 1122. \text{ mm}^2$$

$$J_u = 294439. \text{ mm}^4$$

$$J_v = 72540. \text{ mm}^4$$

$$y_g = 28.61 \text{ mm}$$

$$T_y = 2500. \text{ N}$$

$$M_x = -2250000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.61 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218.7 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

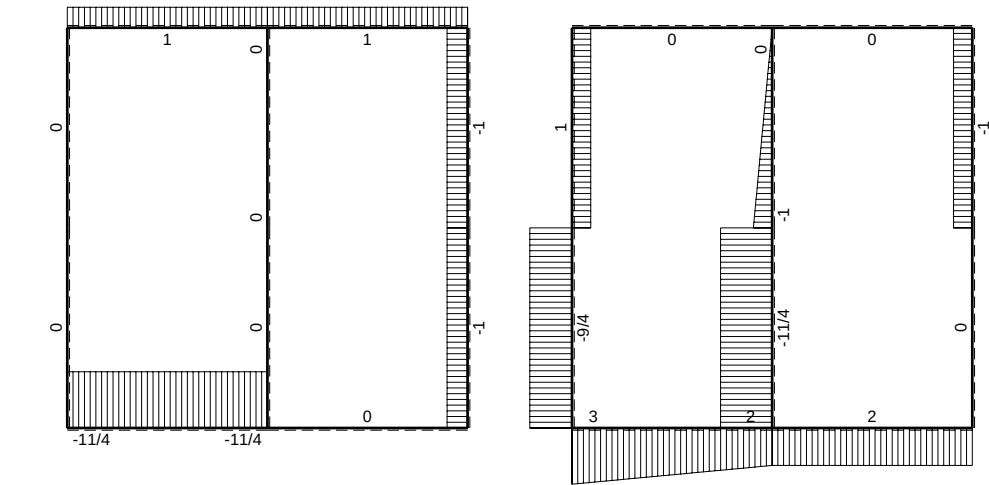
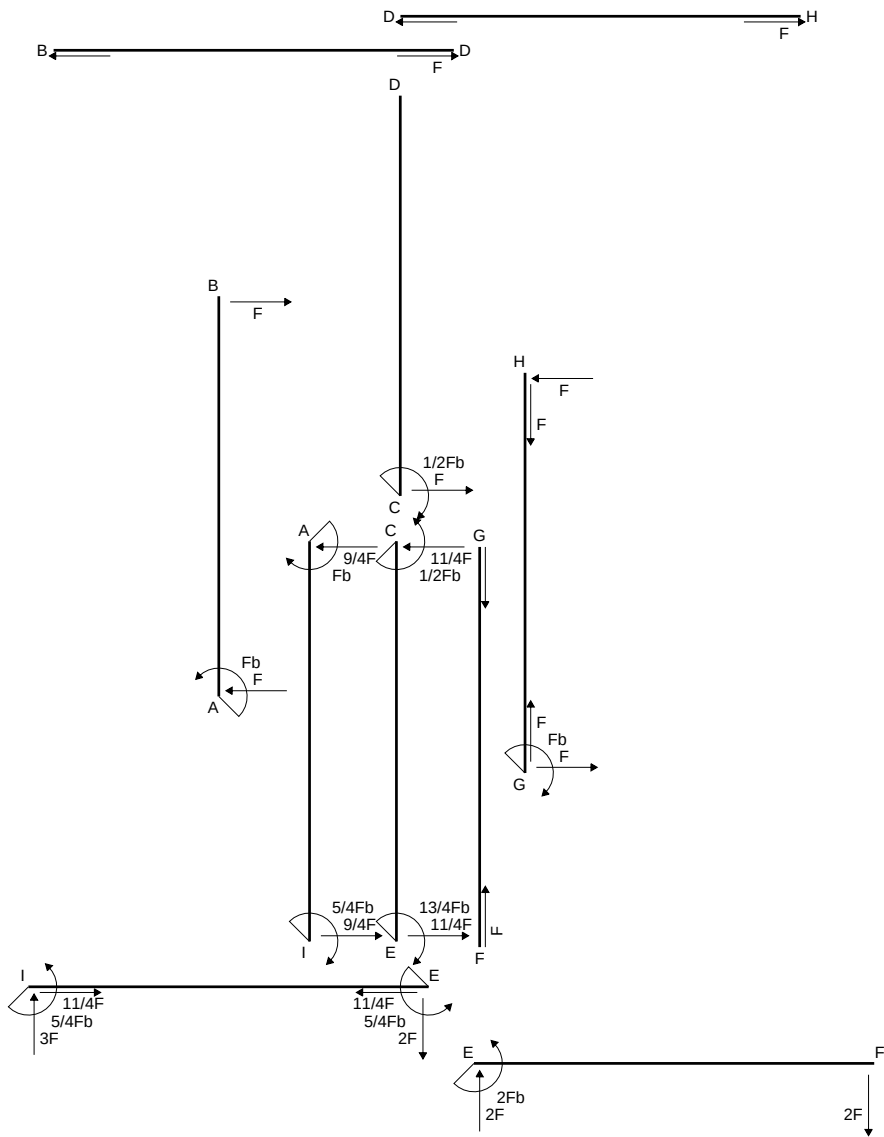
$$v_c = -15.61 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -119.3 \text{ N/mm}^2$$

$$\tau_c = 4.745 \text{ N/mm}^2$$

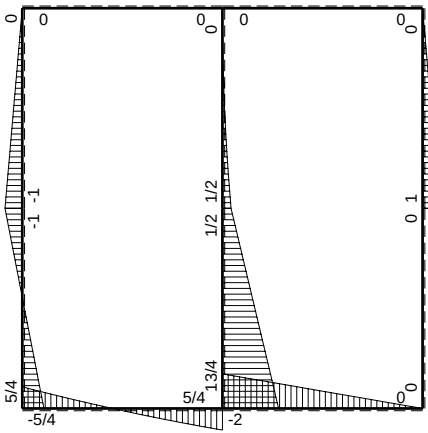
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 119.6 \text{ N/mm}^2$$

$$S = 6706. \text{ mm}^3$$

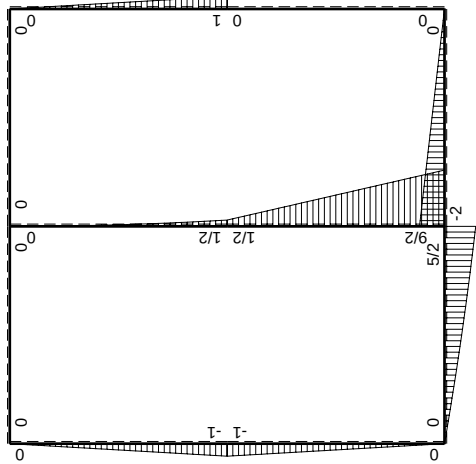
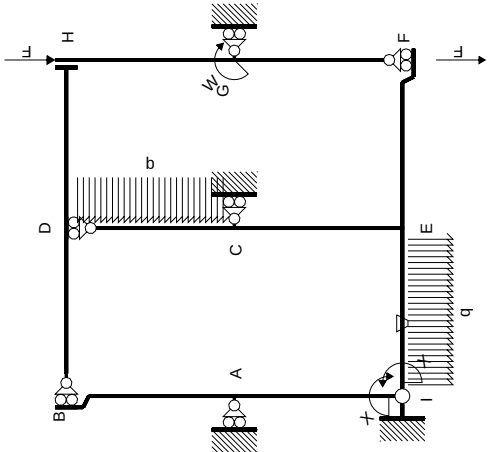


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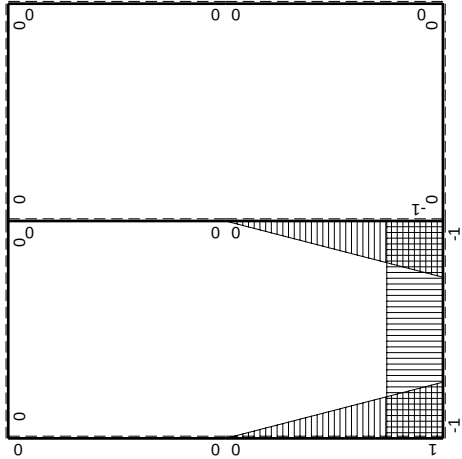


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	-Fb/EJ	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-4Fx$	0	$-9/2Fb+17/2Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-19/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-4Fx$	0	$-1/2Fx-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 17/2 x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 17/4 x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 17/4 b - 4/3 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

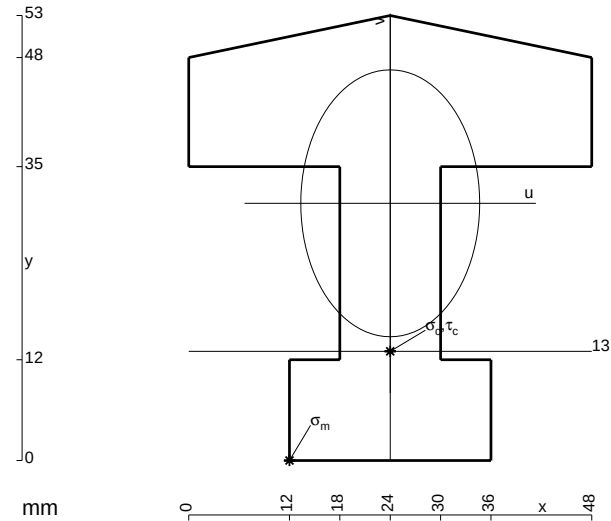
$$= (-1/4 b - 4/3 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1308. \text{ mm}^2$$

$$J_u = 330537. \text{ mm}^4$$

$$J_v = 148464. \text{ mm}^4$$

$$y_g = 30.63 \text{ mm}$$

$$T_y = 2600. \text{ N}$$

$$M_x = -2470000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.63 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -228.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

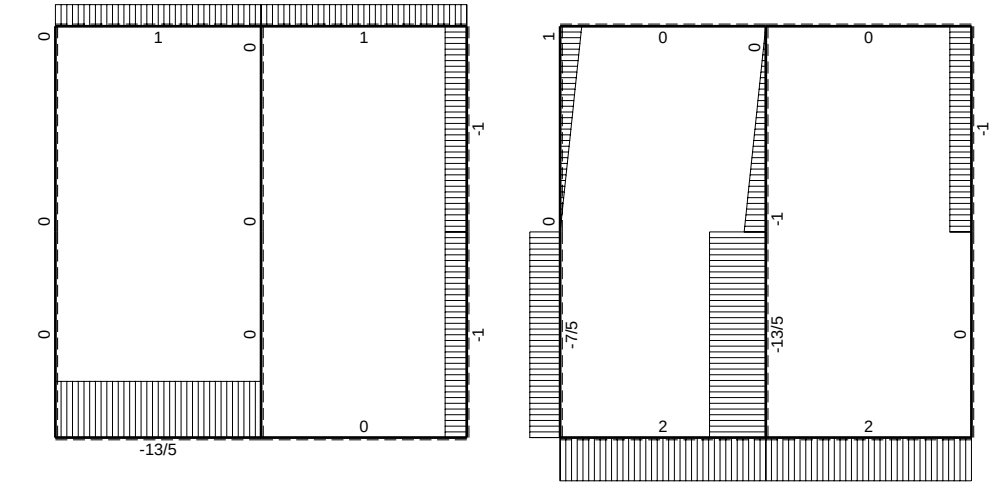
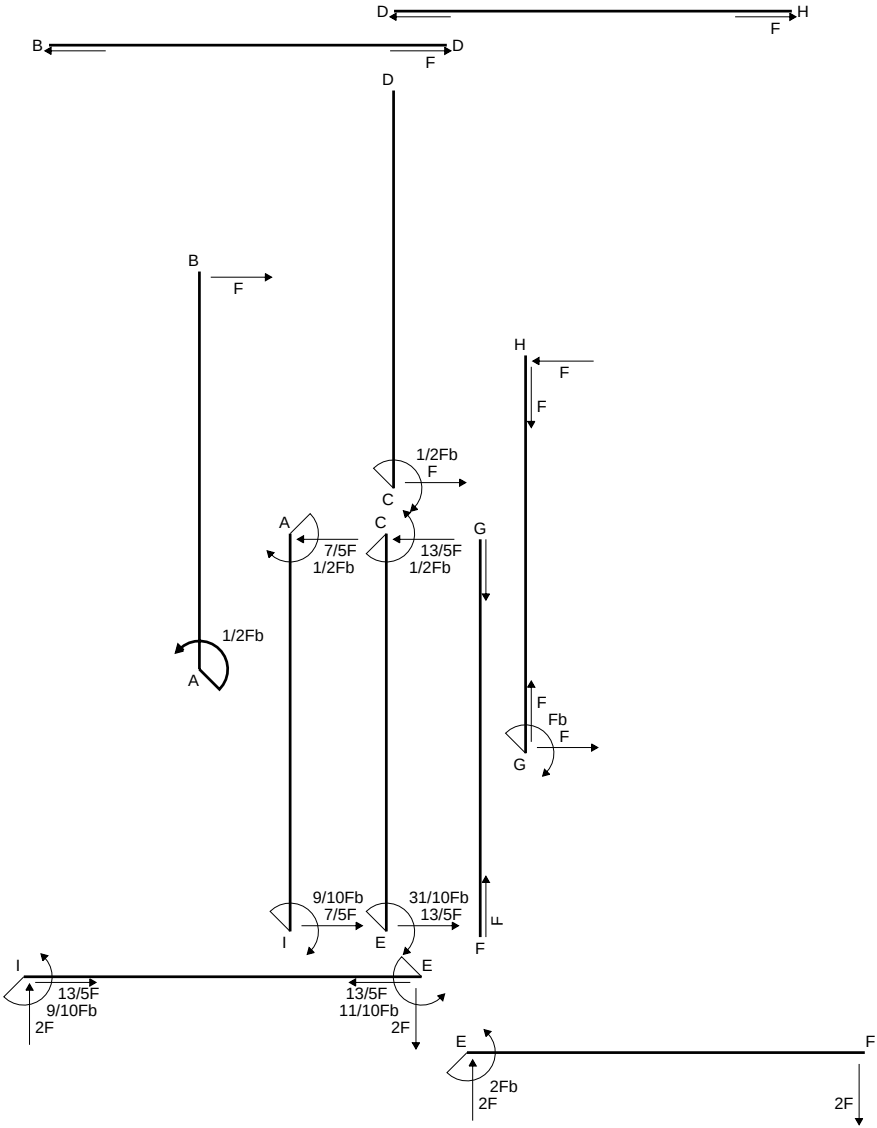
$$v_c = -17.63 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -131.8 \text{ N/mm}^2$$

$$\tau_c = 4.793 \text{ N/mm}^2$$

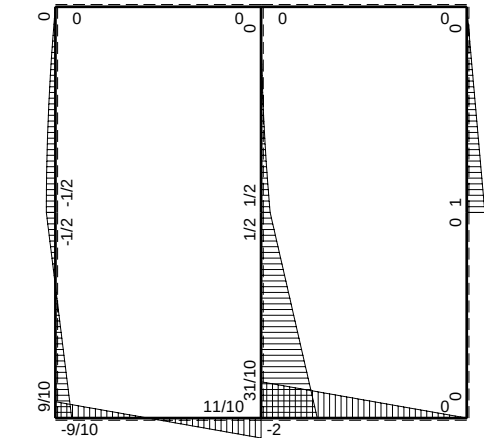
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 132. \text{ N/mm}^2$$

$$S^* = 7312. \text{ mm}^3$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$Fx-1/2qx^2$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$-Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 15/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

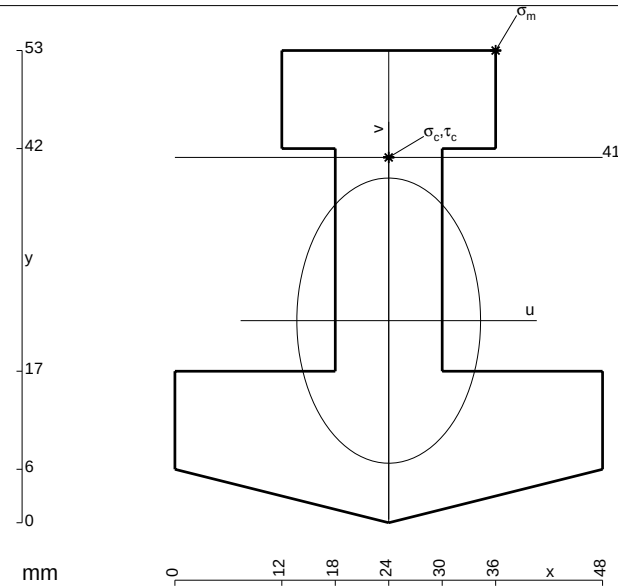
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1236. \text{ mm}^2$$

$$J_u = 316729. \text{ mm}^4$$

$$J_v = 131472. \text{ mm}^4$$

$$y_g = 22.68 \text{ mm}$$

$$T_y = 2500. \text{ N}$$

$$M_x = -2500000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.32 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239.3 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

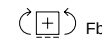
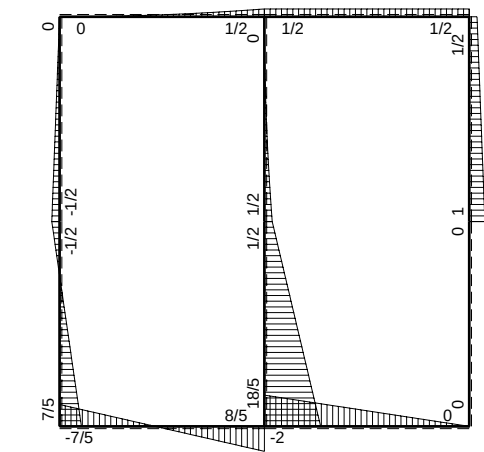
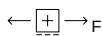
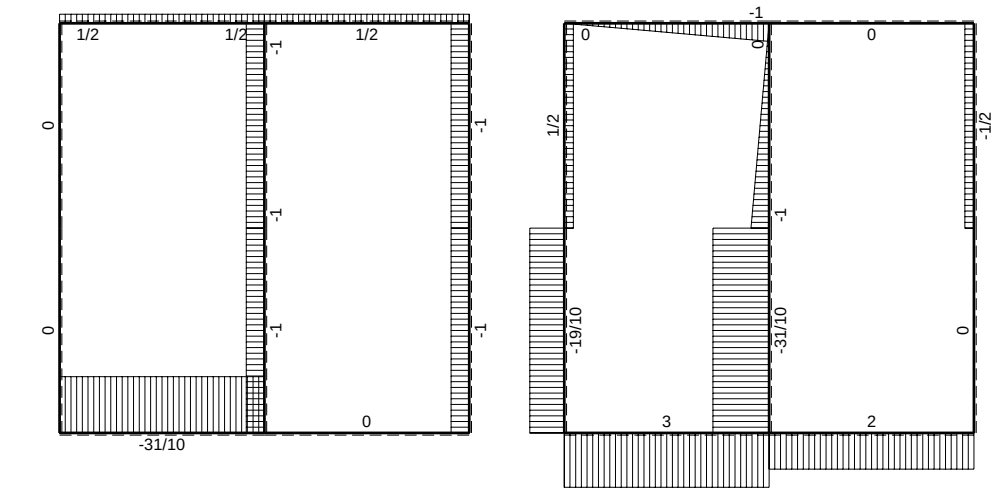
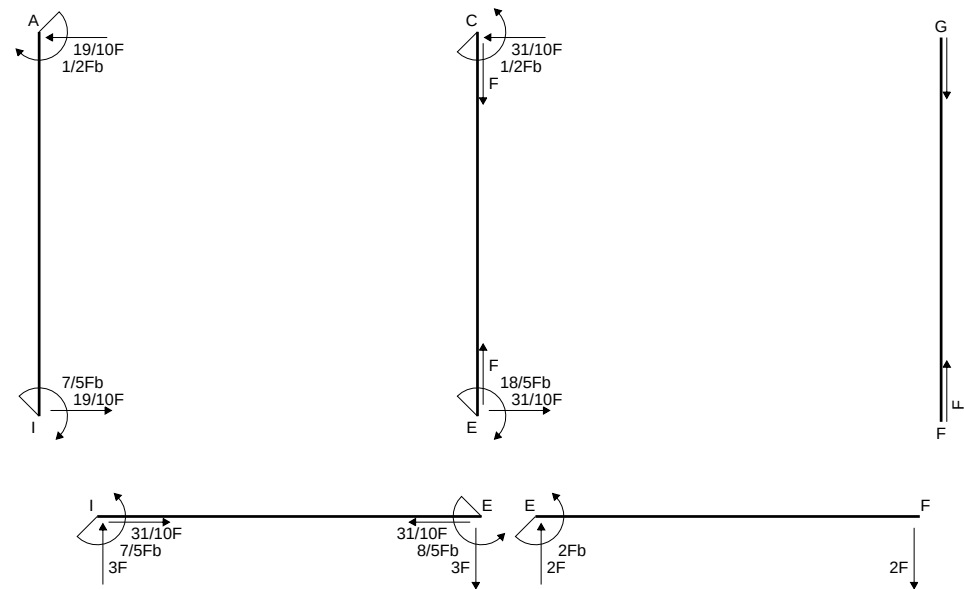
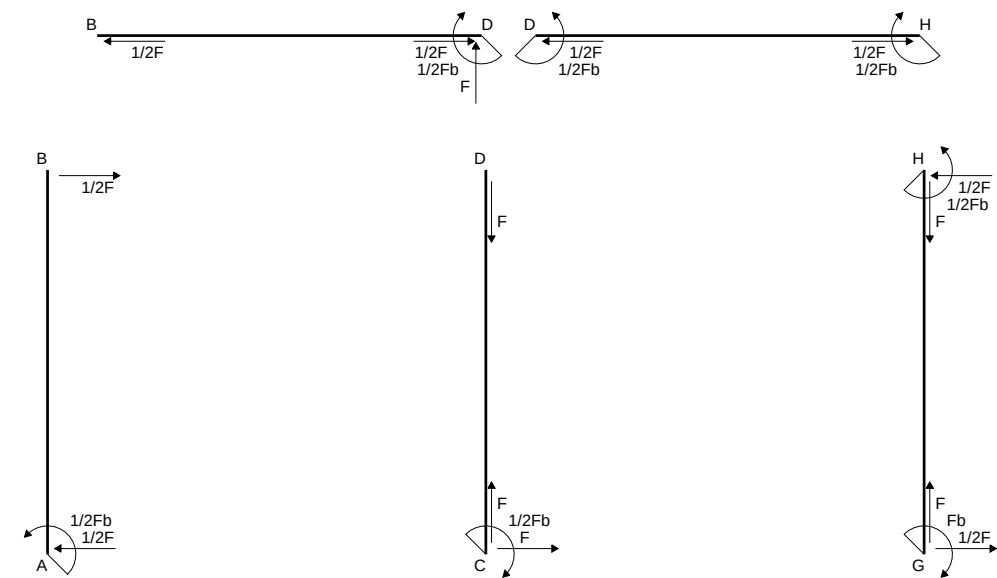
$$v_c = 18.32 \text{ mm}$$

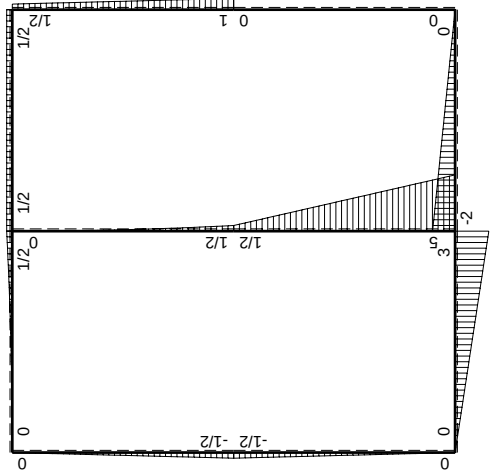
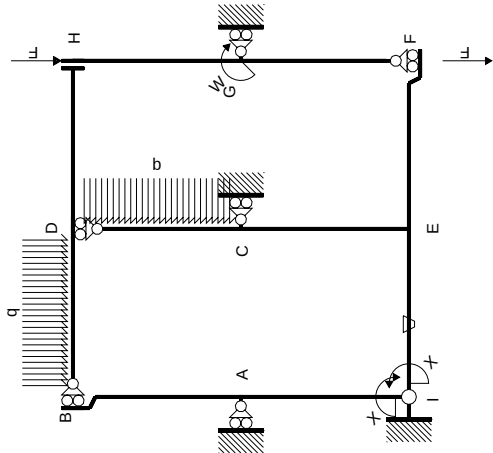
$$\sigma_c = -Mv/J_u = 144.6 \text{ N/mm}^2$$

$$\tau_c = 4.458 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 144.8 \text{ N/mm}^2$$

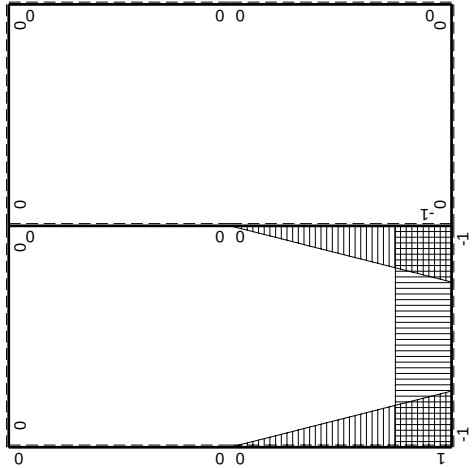
$$S = 6777. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 19/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

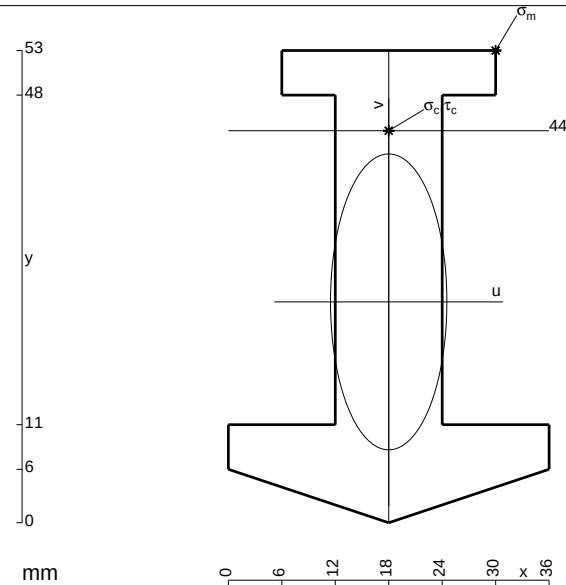
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 852. \text{ mm}^2$$

$$J_u = 235110. \text{ mm}^4$$

$$J_v = 36360. \text{ mm}^4$$

$$y_g = 24.79 \text{ mm}$$

$$T_y = 3140. \text{ N}$$

$$M_x = -1664200. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.21 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199.7 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

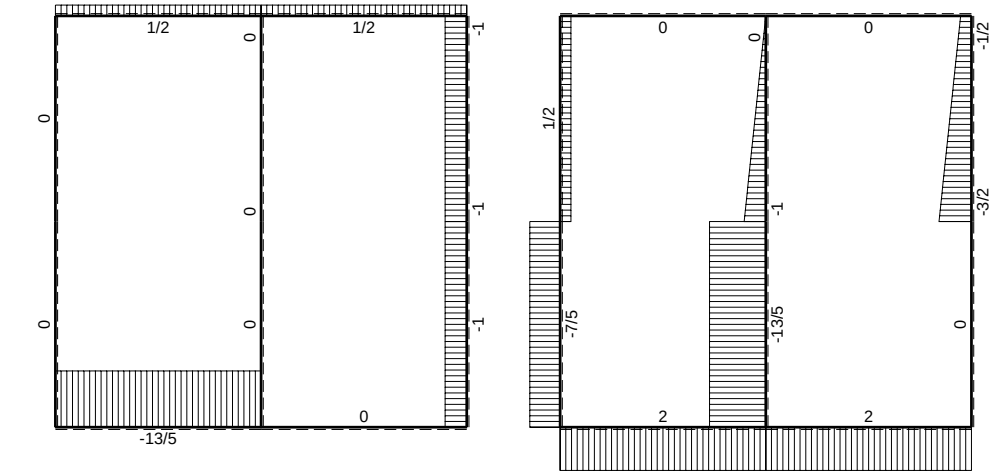
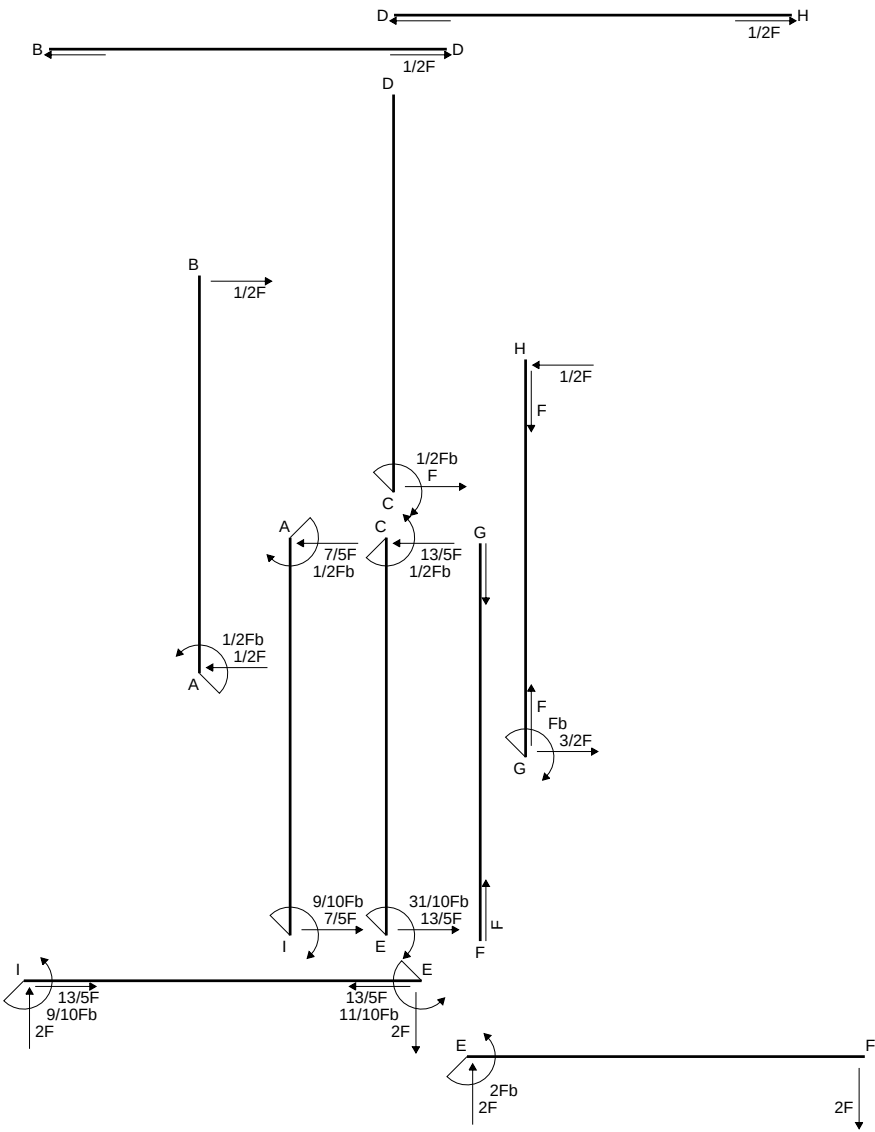
$$v_c = 19.21 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 136. \text{ N/mm}^2$$

$$\tau_c = 4.567 \text{ N/mm}^2$$

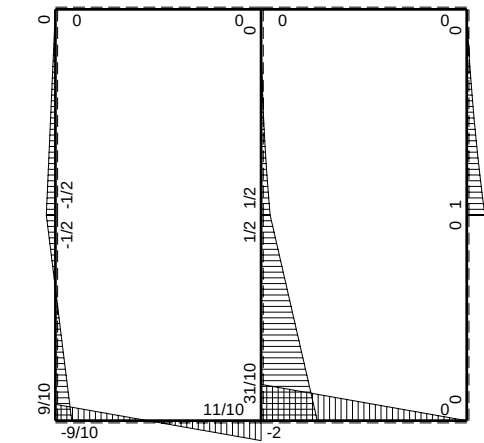
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 136.2 \text{ N/mm}^2$$

$$S = 4103. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 15/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

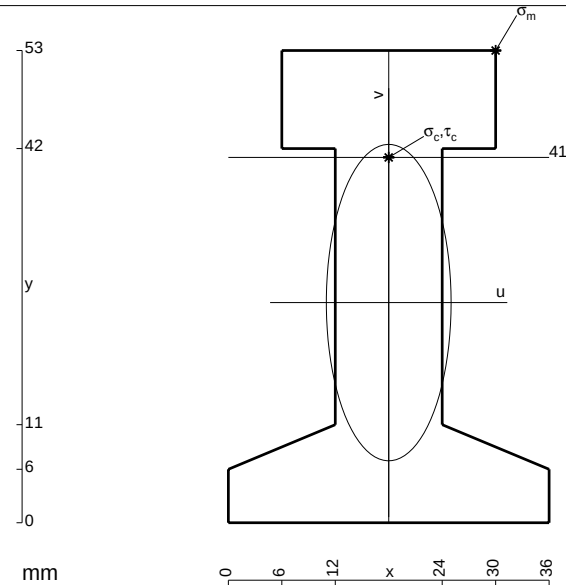
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 972. \text{ mm}^2$$

$$J_u = 306619. \text{ mm}^4$$

$$J_v = 47664. \text{ mm}^4$$

$$y_g = 24.71 \text{ mm}$$

$$T_y = 3920. \text{ N}$$

$$M_x = -2273600. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.29 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.8 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

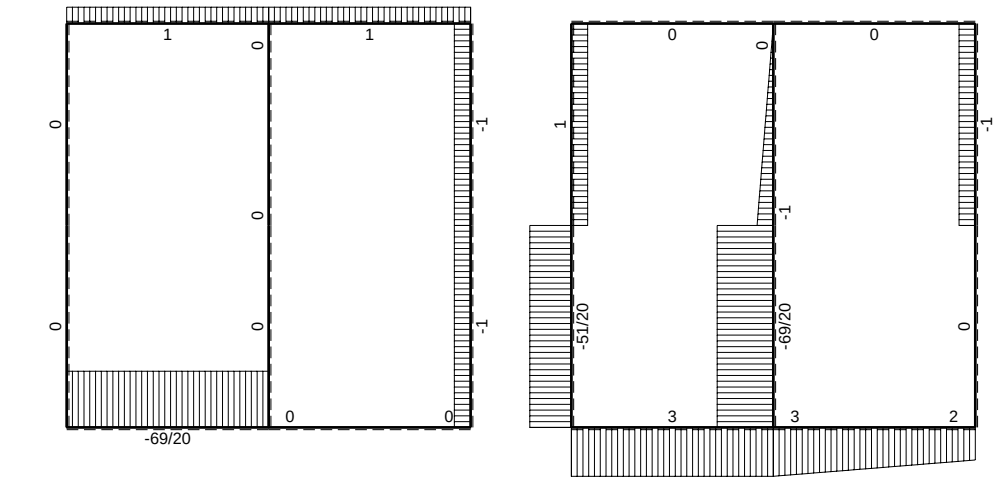
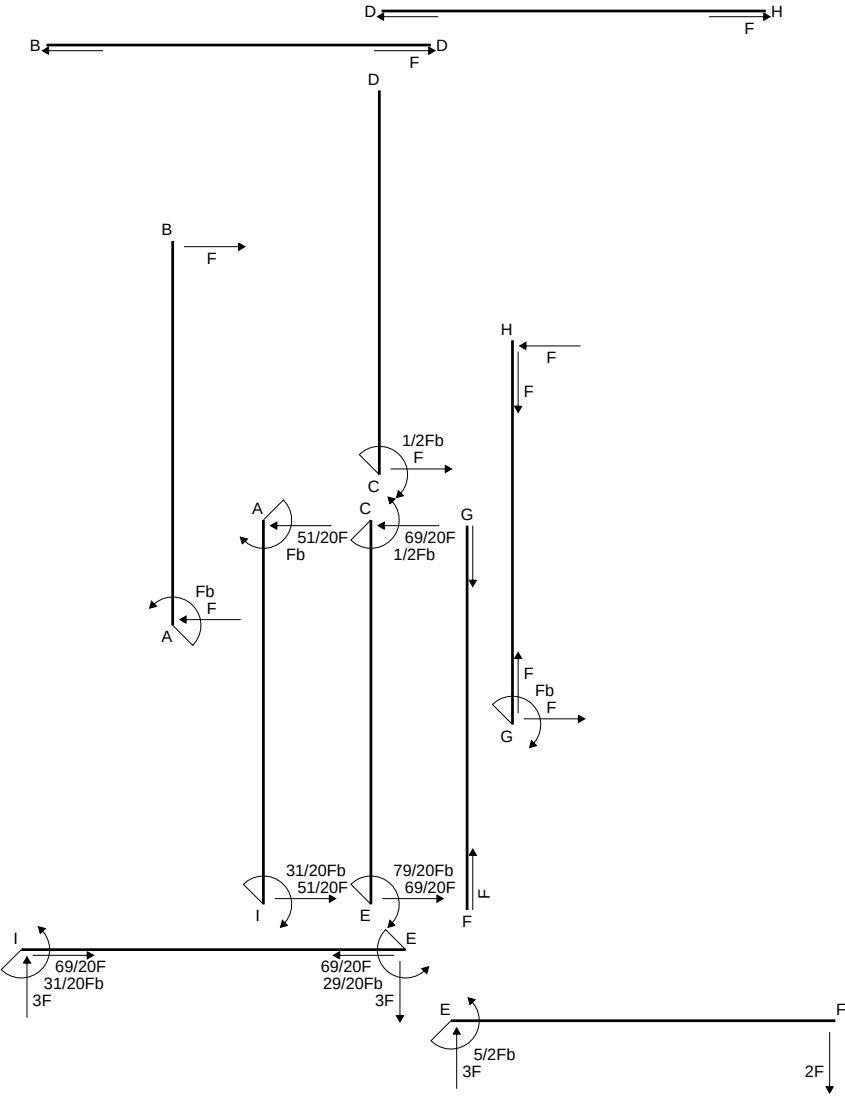
$$v_c = 16.29 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 120.8 \text{ N/mm}^2$$

$$\tau_c = 6.625 \text{ N/mm}^2$$

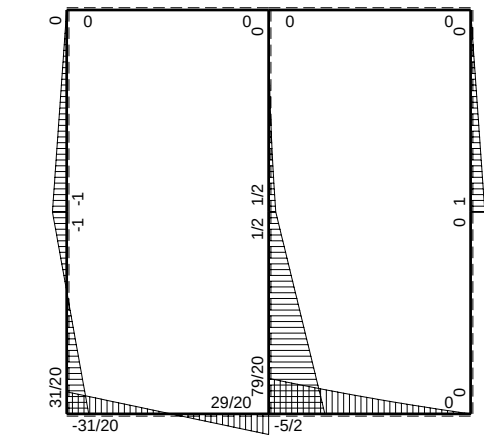
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 121.4 \text{ N/mm}^2$$

$$S = 6219. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F_b

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	Fb-Fx	0	0	0	0	0+0	0
HG b	0	-Fx	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-5Fx$	0	$-11/2Fb+21/2Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-23/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-5Fx$	0	$-1/2Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	Fb-Fx	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 21/2 x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 21/4 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 21/4 b - 5/3 b) Fb \frac{1}{EJ} = -23/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

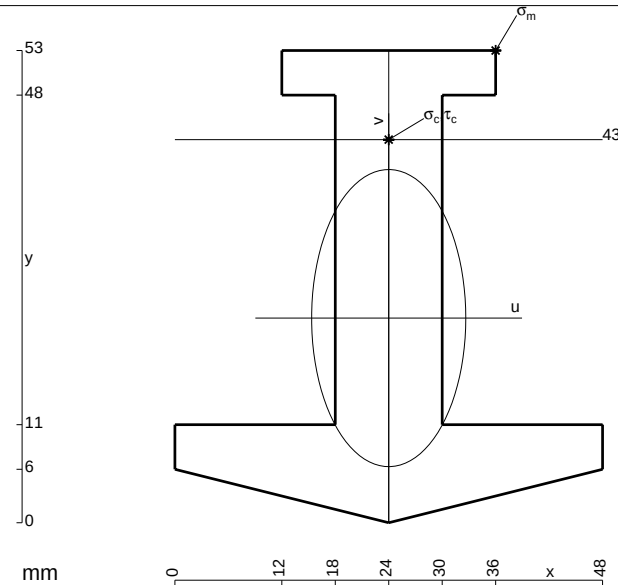
$$= (-1/4 b - 5/3 b) Fb \frac{1}{EJ} = -23/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

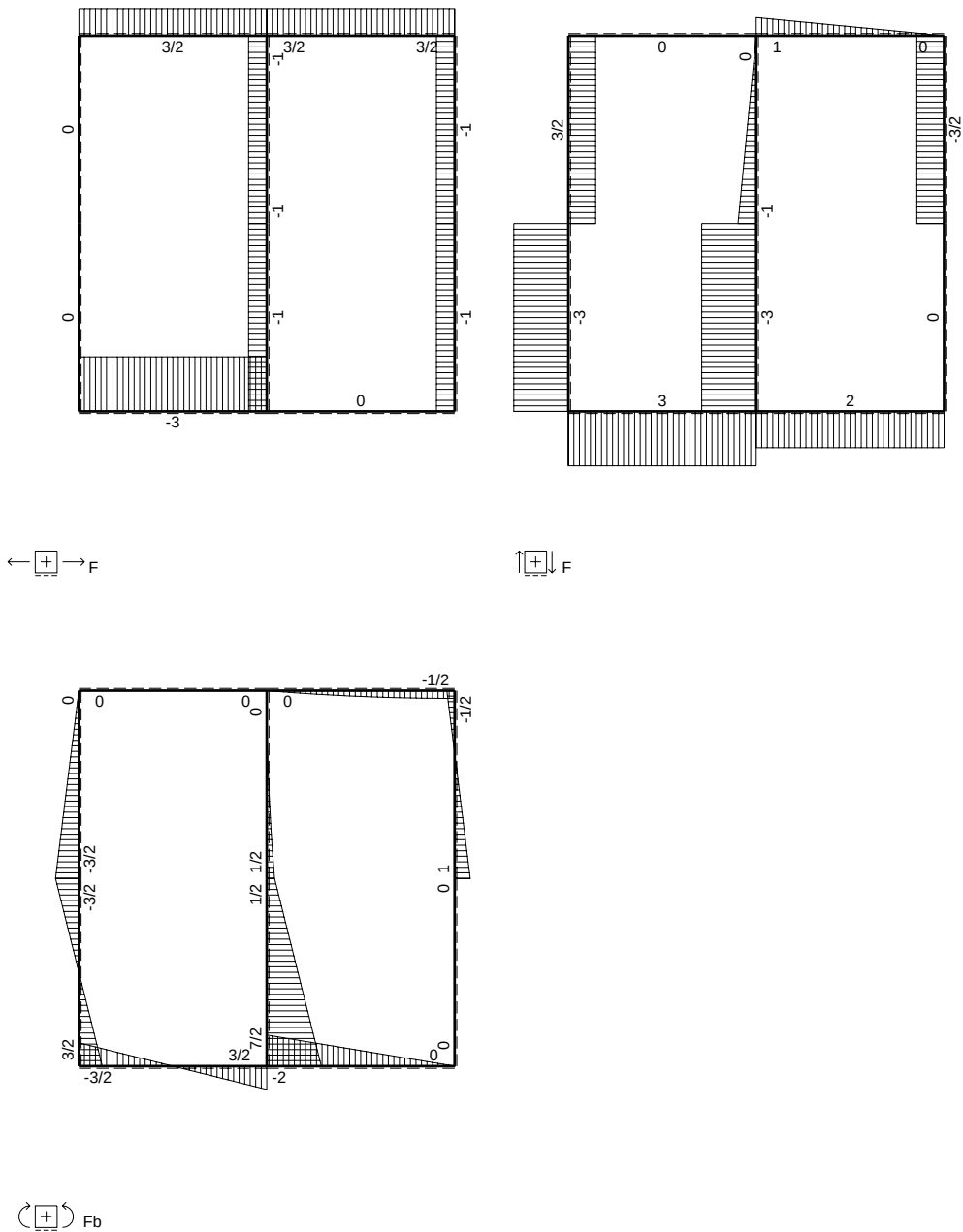
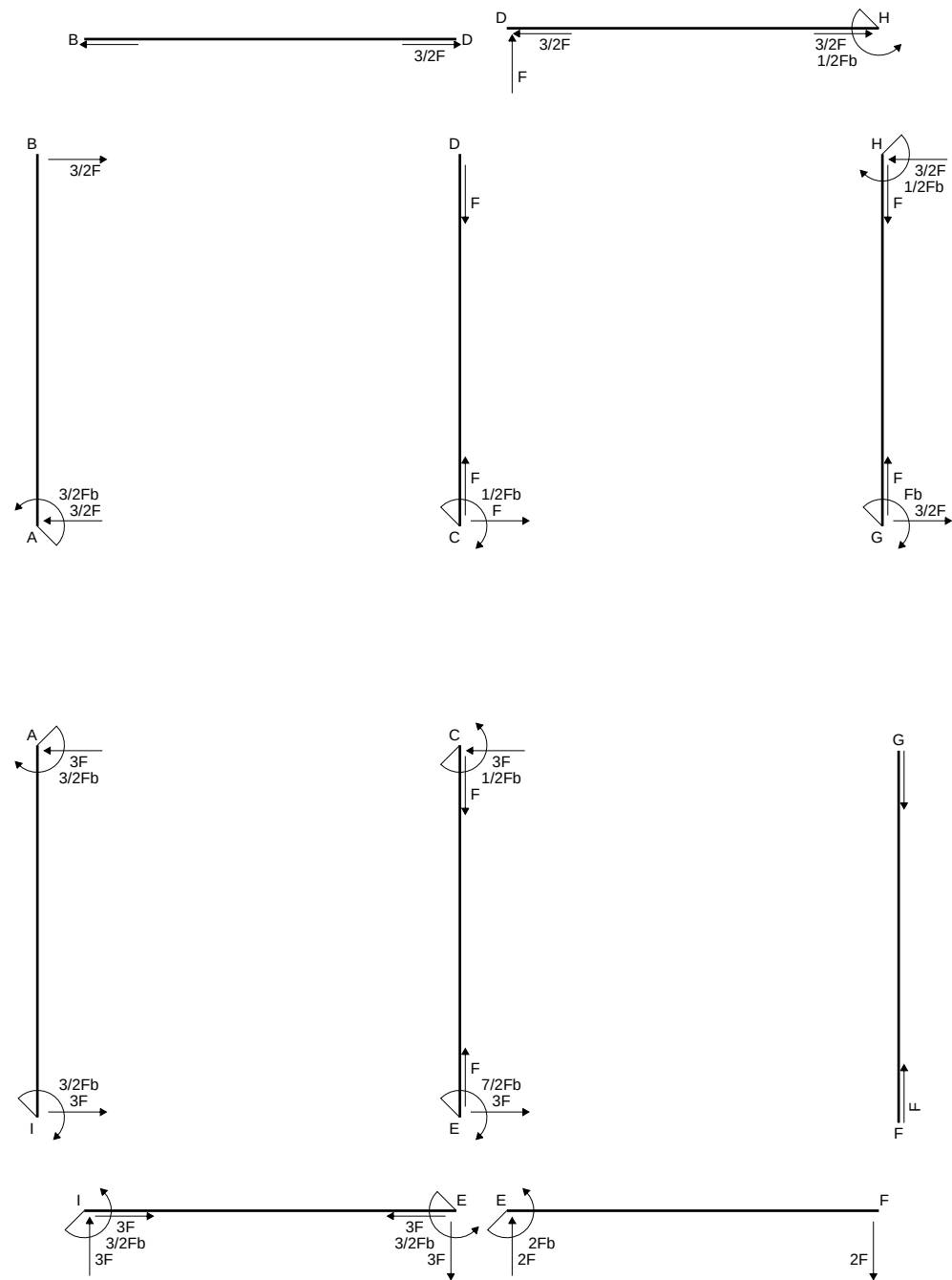
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

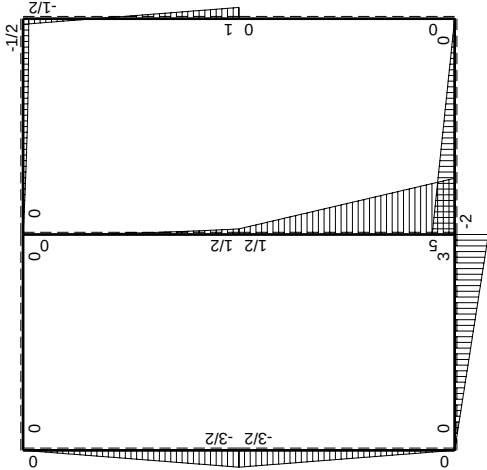
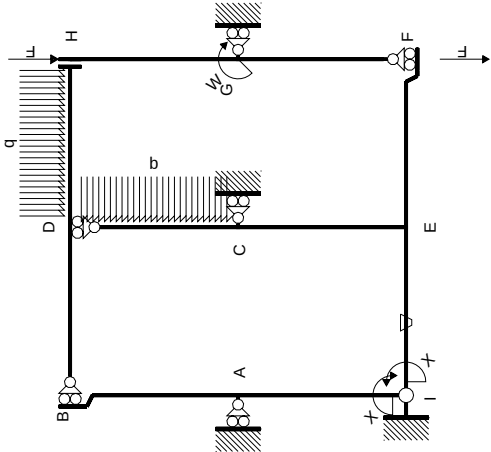
$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



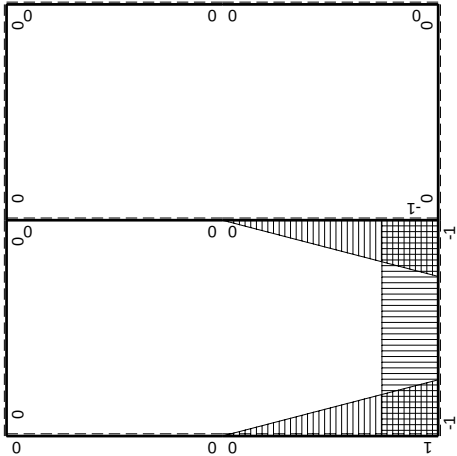
$$\begin{aligned} A &= 948. \text{ mm}^2 \\ J_u &= 263643. \text{ mm}^4 \\ J_v &= 70992. \text{ mm}^4 \\ y_g &= 22.97 \text{ mm} \\ T_y &= 3660. \text{ N} \\ M_x &= -1921500. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.03 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 43. \text{ mm} \\ v_c &= 20.03 \text{ mm} \\ \sigma_c &= -Mv/J_u = 146. \text{ N/mm}^2 \\ \tau_c &= 5.386 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 146.3 \text{ N/mm}^2 \\ S &= 4656. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-3/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 19/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

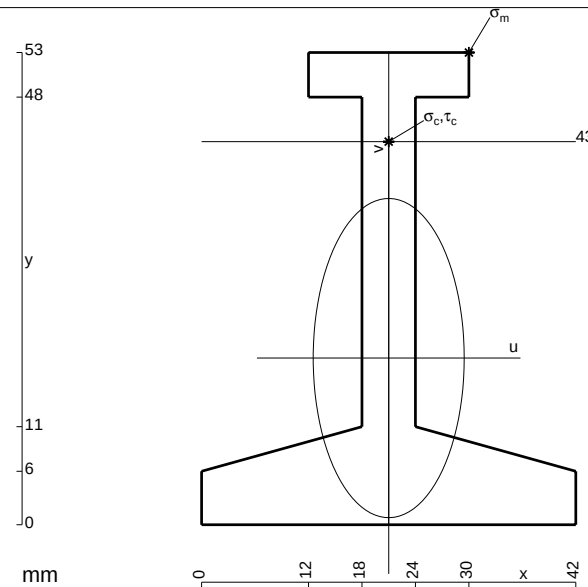
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 684. \text{ mm}^2$$

$$J_u = 219556. \text{ mm}^4$$

$$J_v = 49140. \text{ mm}^4$$

$$y_g = 18.71 \text{ mm}$$

$$T_y = 2160. \text{ N}$$

$$M_x = -1468800. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 34.29 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

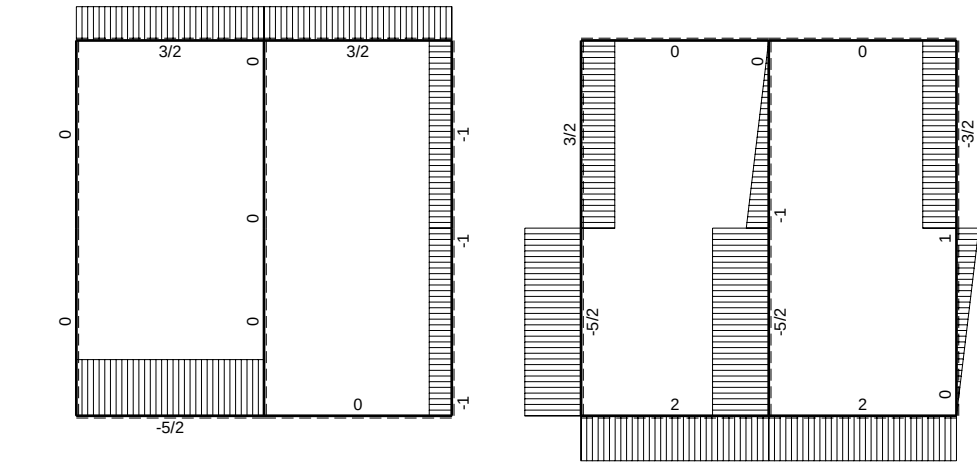
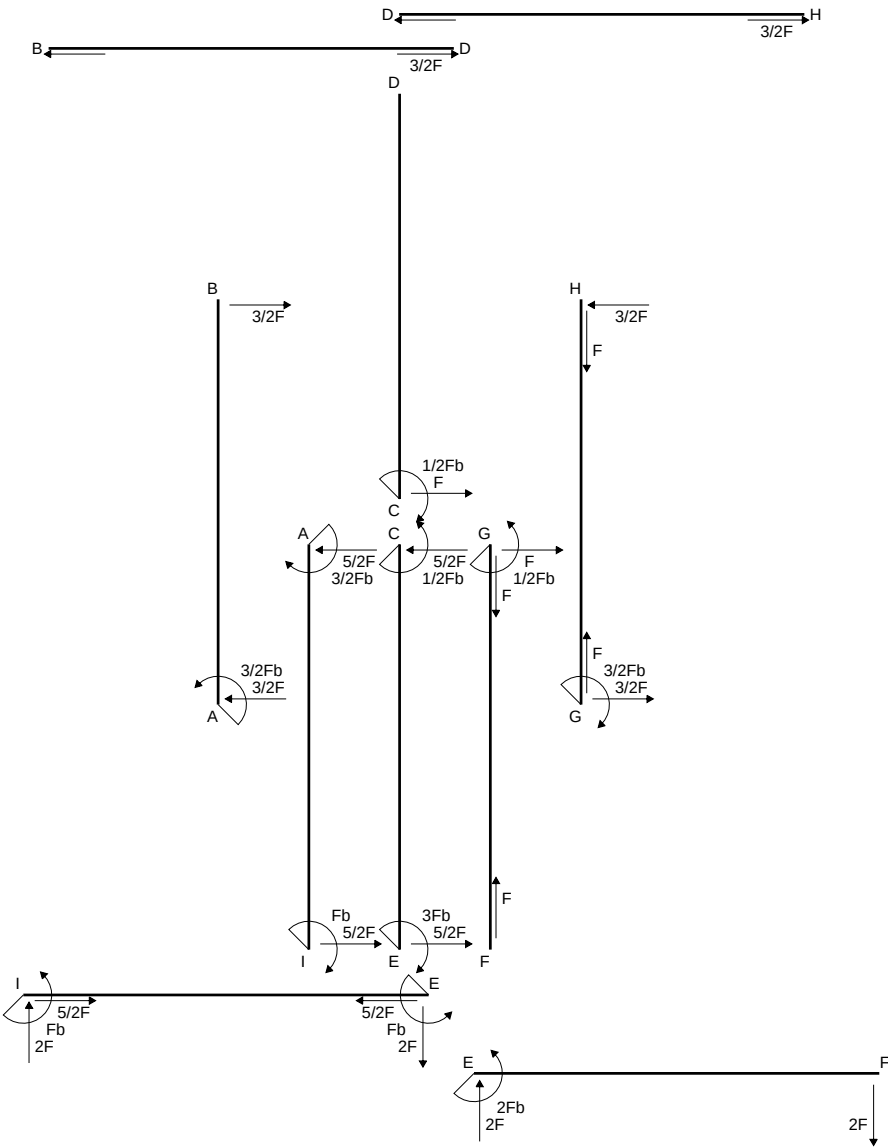
$$v_c = 24.29 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 162.5 \text{ N/mm}^2$$

$$\tau_c = 6.01 \text{ N/mm}^2$$

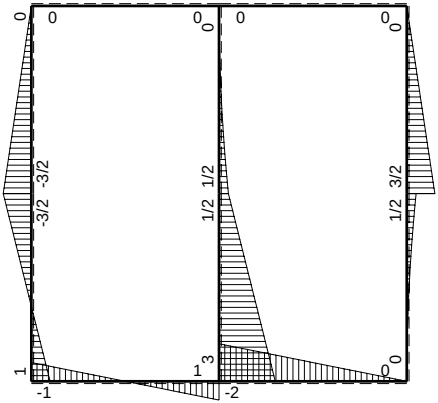
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 162.9 \text{ N/mm}^2$$

$$S = 3665. \text{ mm}^3$$

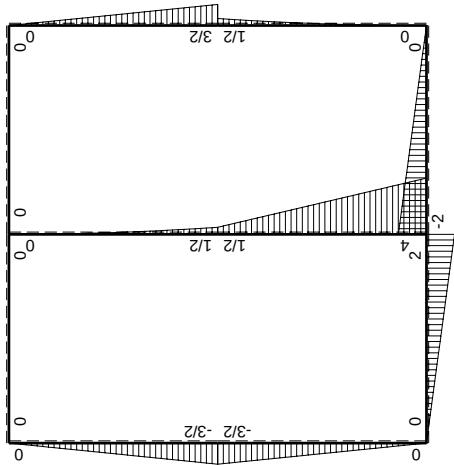
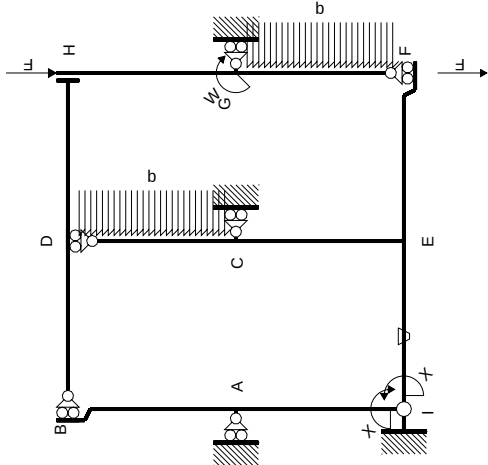


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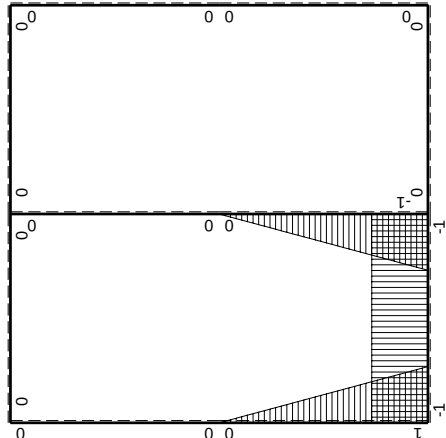


⊕ ⊖ F_b



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-3/2Fb+3/2Fx$	0	0	0	0	0+0	0
BA b	0	$3/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$3/2Fb-3/2Fx$	0	0	0	0	0+0	0
HG b	0	$-3/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-7/2Fx$	0	$-4Fb+15/2Fx-7/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-17/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-7/2Fx$	0	$-1/2Fx-7/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 15/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 15/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 15/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 7/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 7/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

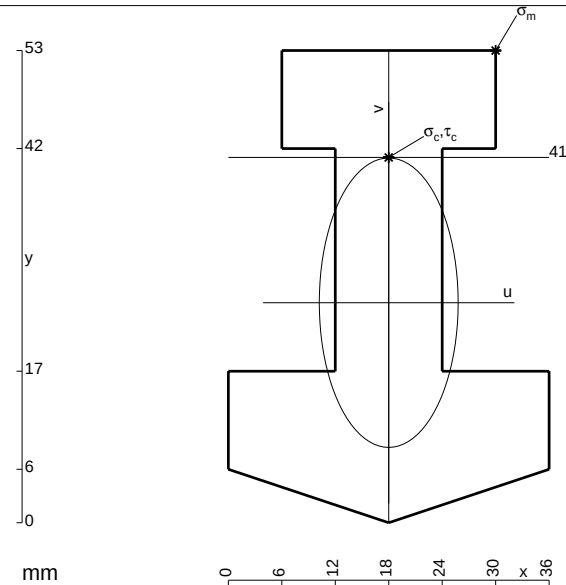
$$= (-1/4 b - 7/6 b) Fb \frac{1}{EJ} = -17/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 1068. \text{ mm}^2$$

$$J_u = 281922. \text{ mm}^4$$

$$J_v = 64872. \text{ mm}^4$$

$$y_g = 24.7 \text{ mm}$$

$$T_y = 3220. \text{ N}$$

$$M_x = -2382800. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.3 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 239.2 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

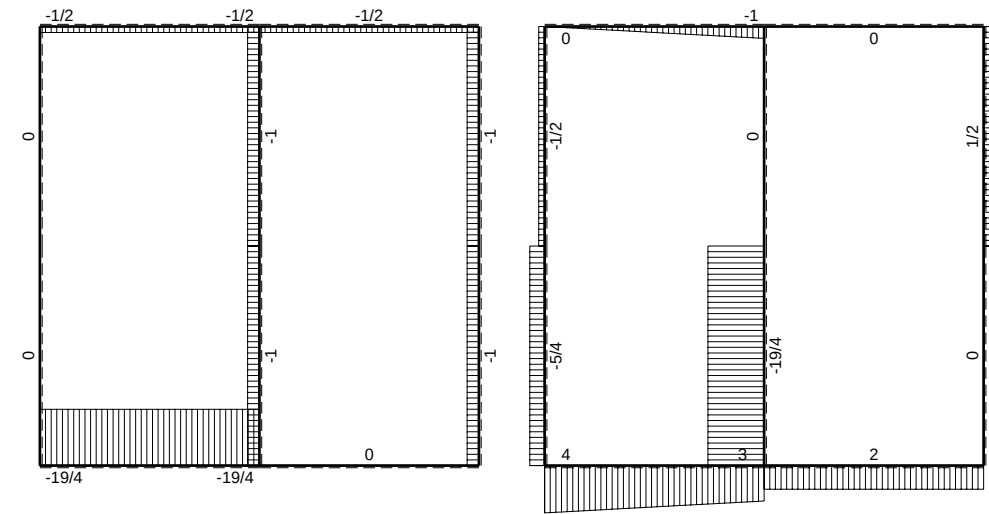
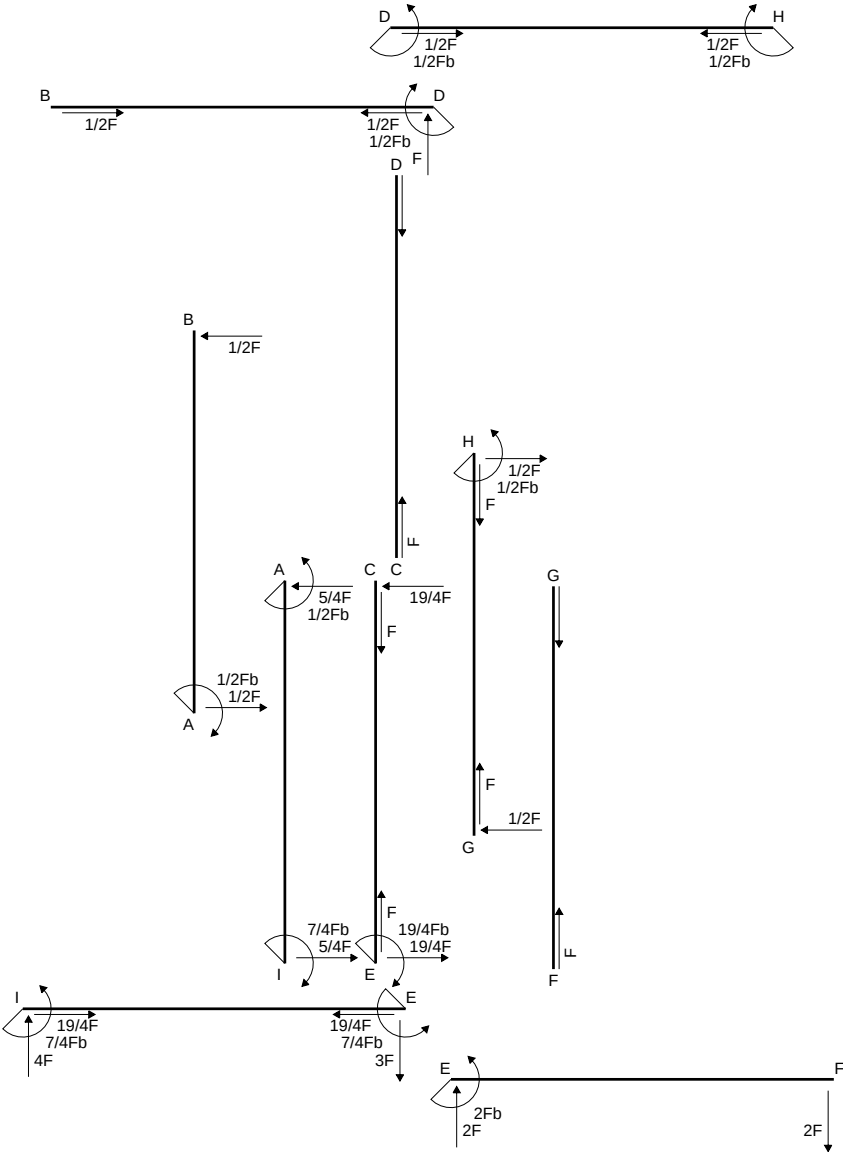
$$v_c = 16.3 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 137.8 \text{ N/mm}^2$$

$$\tau_c = 5.922 \text{ N/mm}^2$$

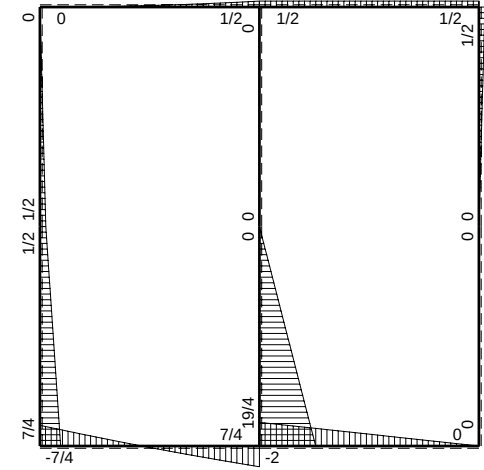
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 138.2 \text{ N/mm}^2$$

$$S = 6222. \text{ mm}^3$$

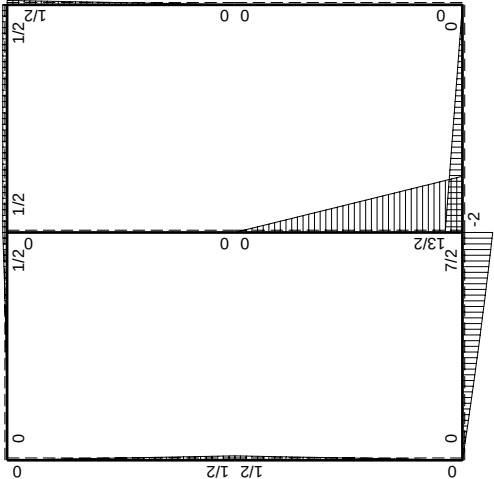
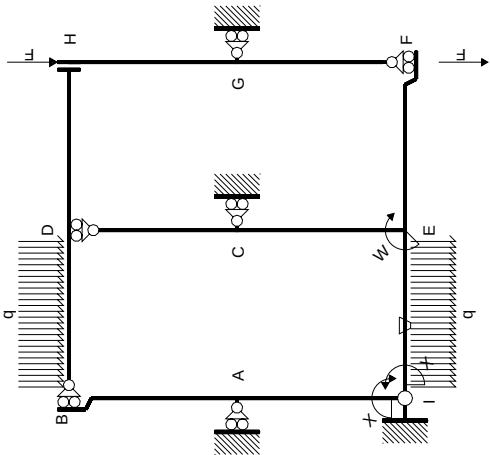


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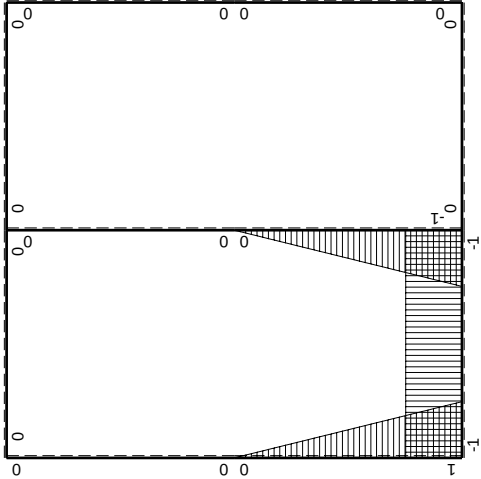


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

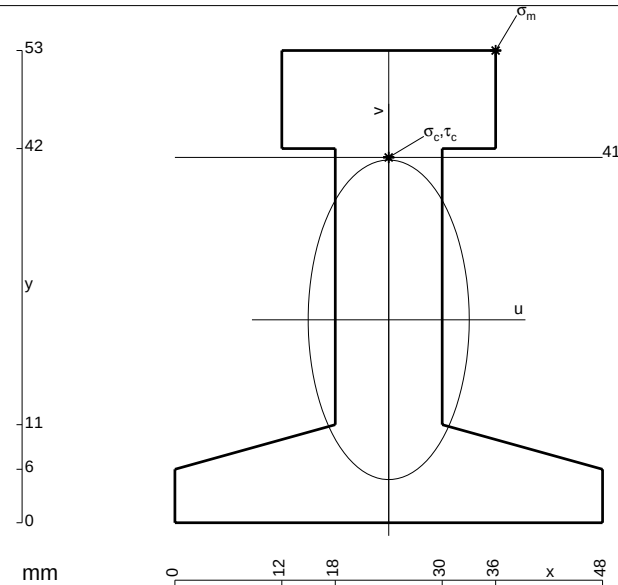
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 1074. \text{ mm}^2$$

$$J_u = 345511. \text{ mm}^4$$

$$J_v = 87732. \text{ mm}^4$$

$$y_g = 22.78 \text{ mm}$$

$$T_y = 2880. \text{ N}$$

$$M_x = -2275200. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.22 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199. \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

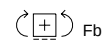
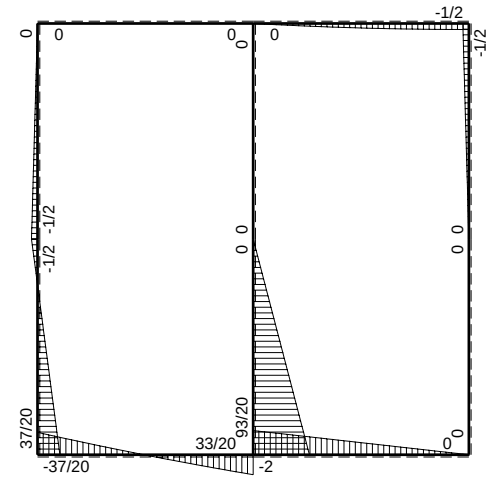
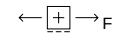
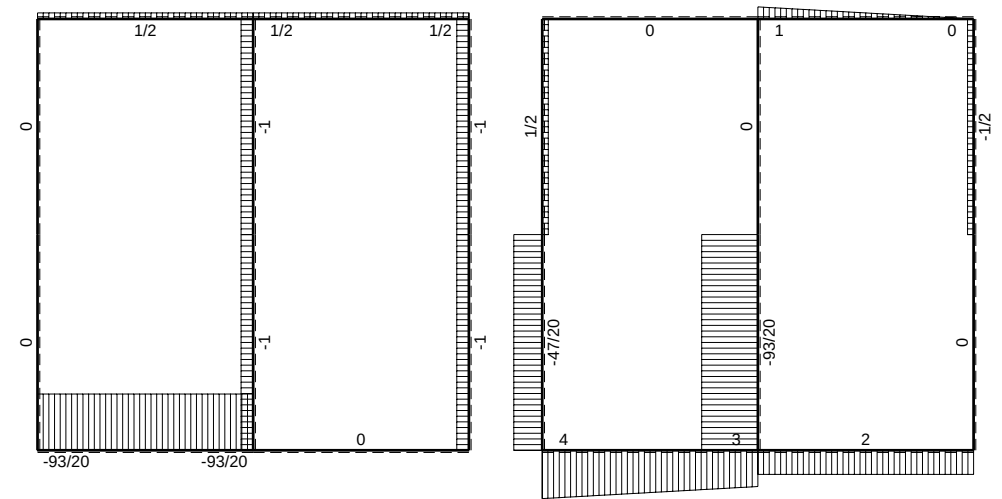
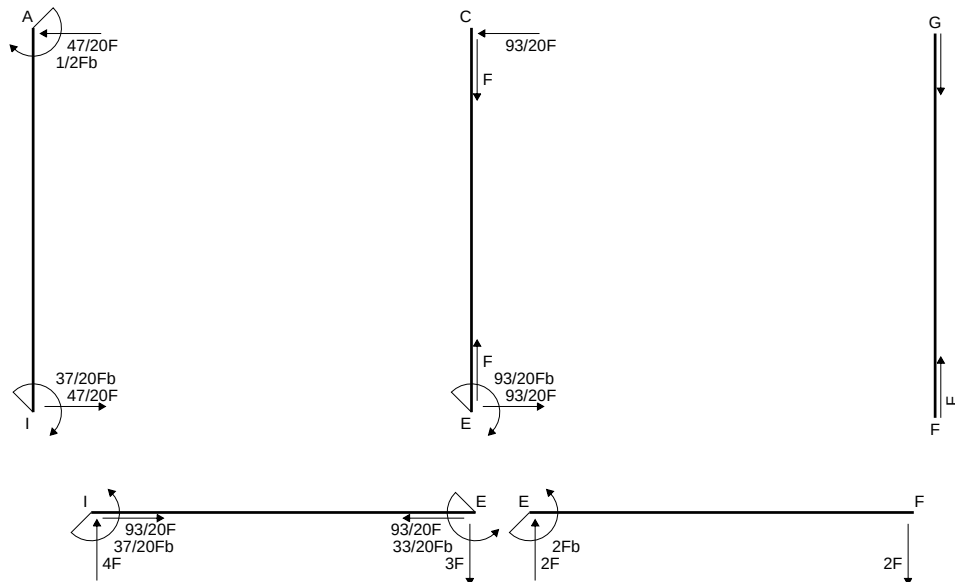
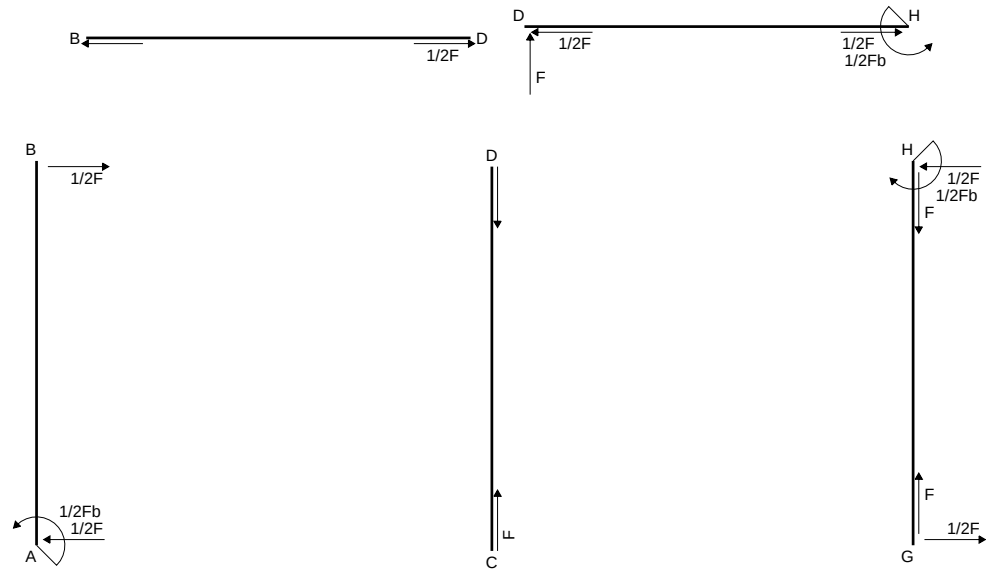
$$v_c = 18.22 \text{ mm}$$

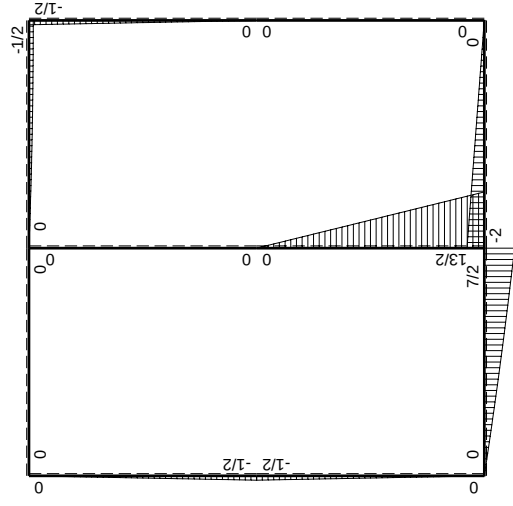
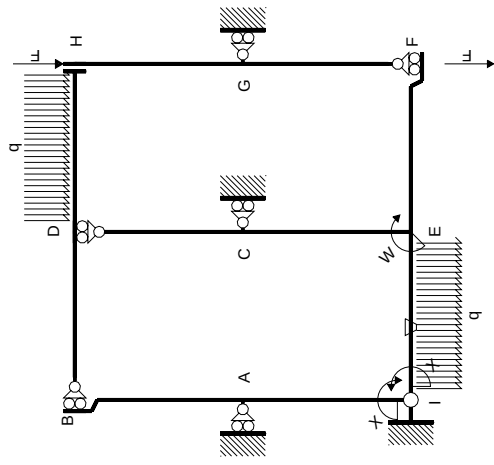
$$\sigma_c = -Mv/J_u = 120. \text{ N/mm}^2$$

$$\tau_c = 4.69 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 120.3 \text{ N/mm}^2$$

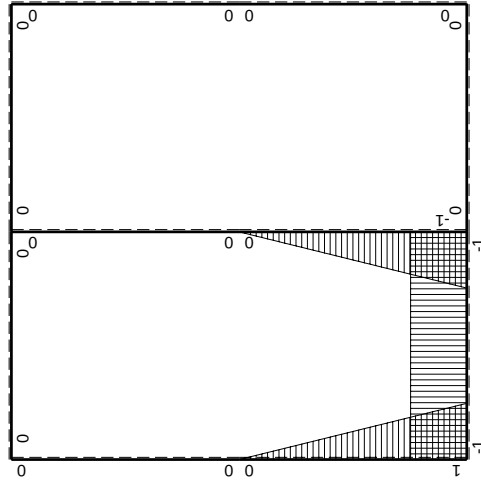
$$S = 6752. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-37/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$37/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

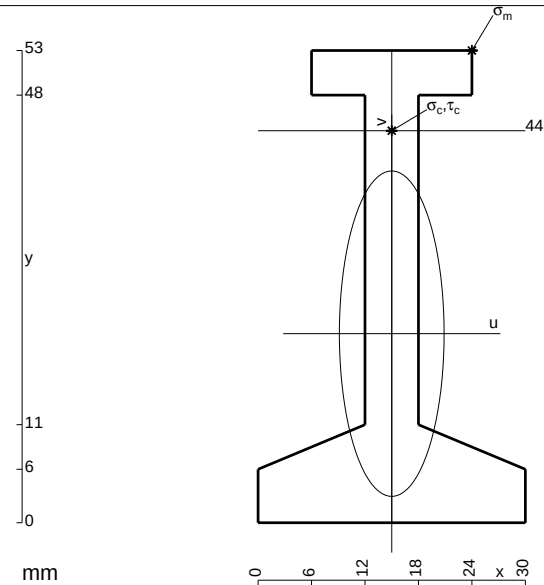
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 582. \text{ mm}^2$$

$$J_u = 194208. \text{ mm}^4$$

$$J_v = 20106. \text{ mm}^4$$

$$y_g = 21.22 \text{ mm}$$

$$T_y = 1520. \text{ N}$$

$$M_x = -1276800. \text{ Nmm}$$

$$x_m = 24. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 31.78 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.9 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

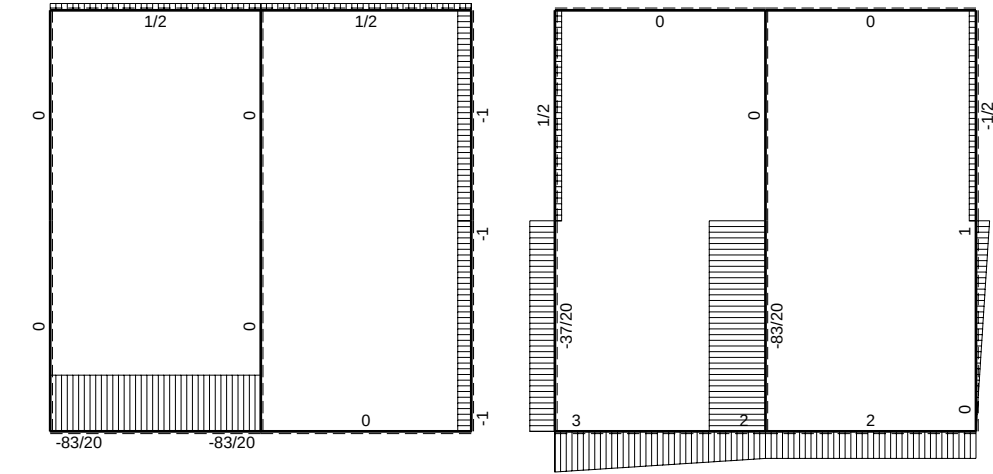
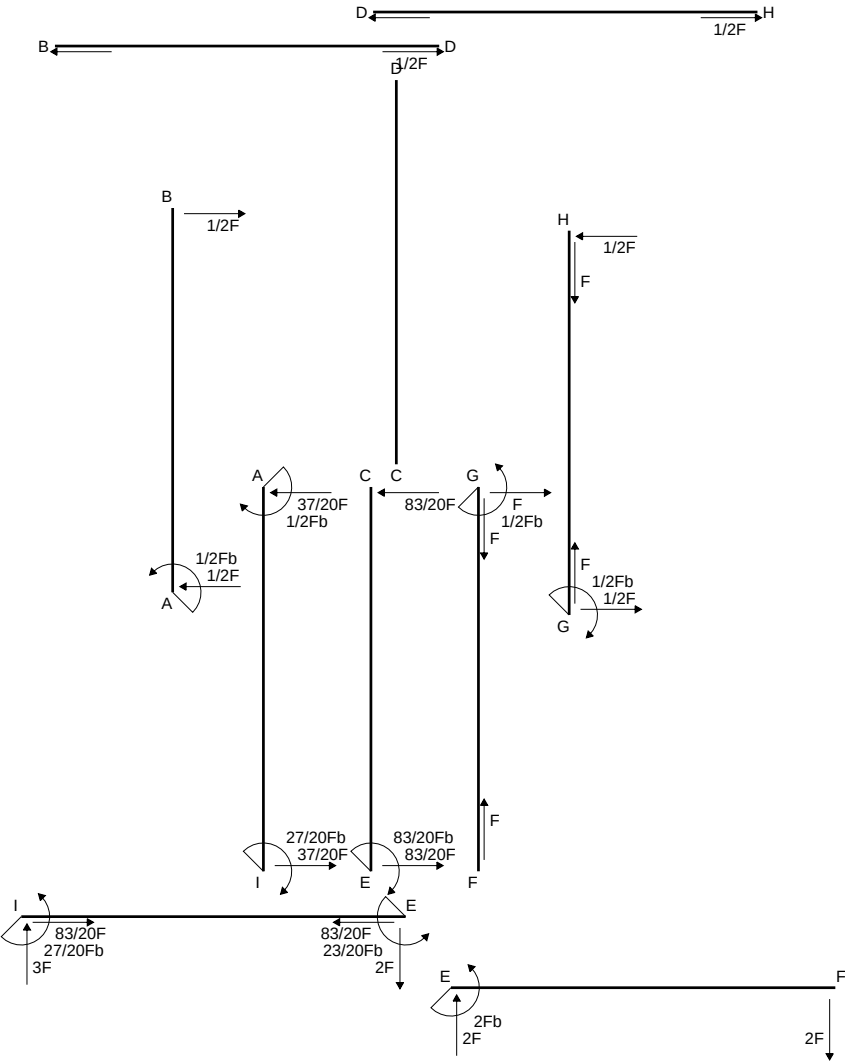
$$v_c = 22.78 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 149.8 \text{ N/mm}^2$$

$$\tau_c = 4.214 \text{ N/mm}^2$$

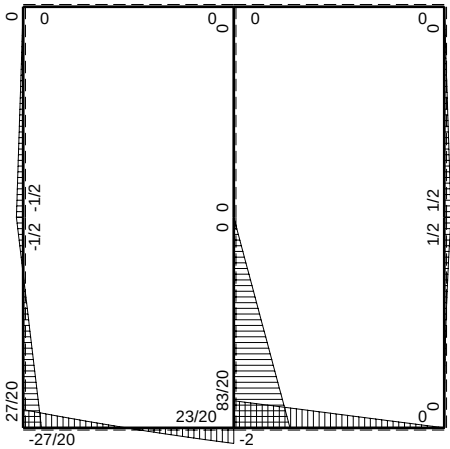
$$\sigma_\varphi = \sqrt{\sigma^2 + 3\tau^2} = 150. \text{ N/mm}^2$$

$$S = 3230. \text{ mm}^3$$

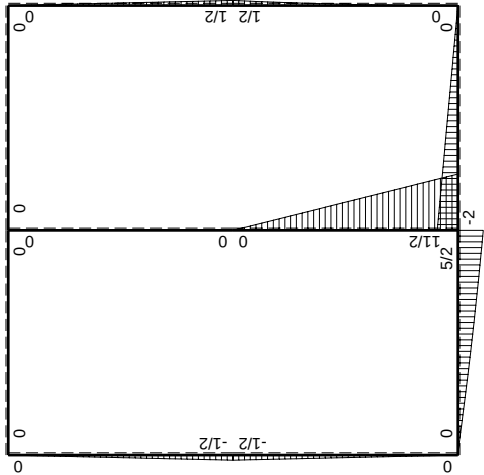
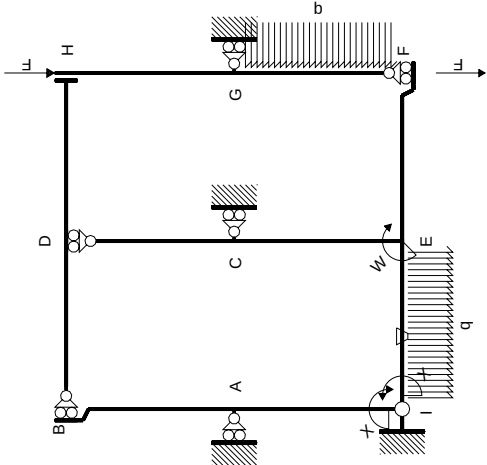


← ⊕ → F

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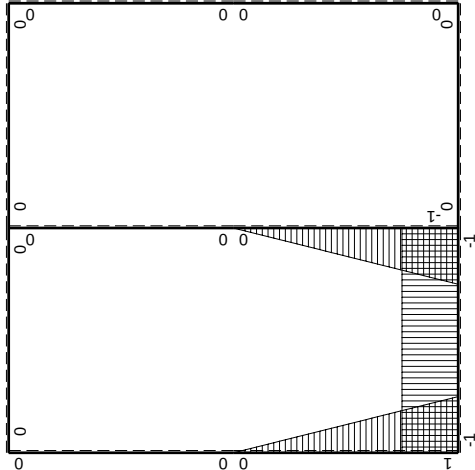


⊕ ⊗ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-9/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$27/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

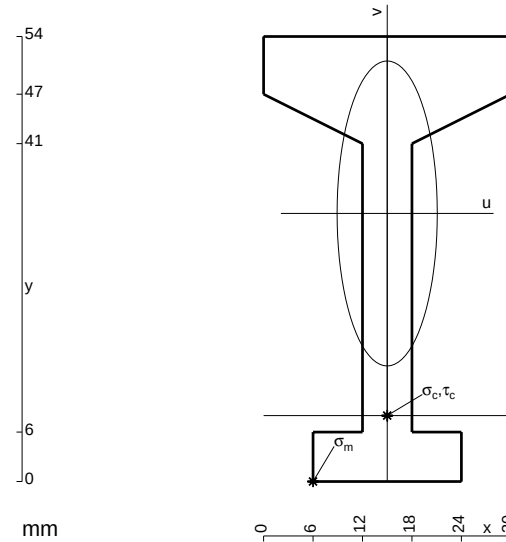
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 636. \text{ mm}^2$$

$$J_u = 217919. \text{ mm}^4$$

$$J_v = 23508. \text{ mm}^4$$

$$y_g = 32.53 \text{ mm}$$

$$T_y = 1600. \text{ N}$$

$$M_x = -1456000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -32.53 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -217.3 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 8. \text{ mm}$$

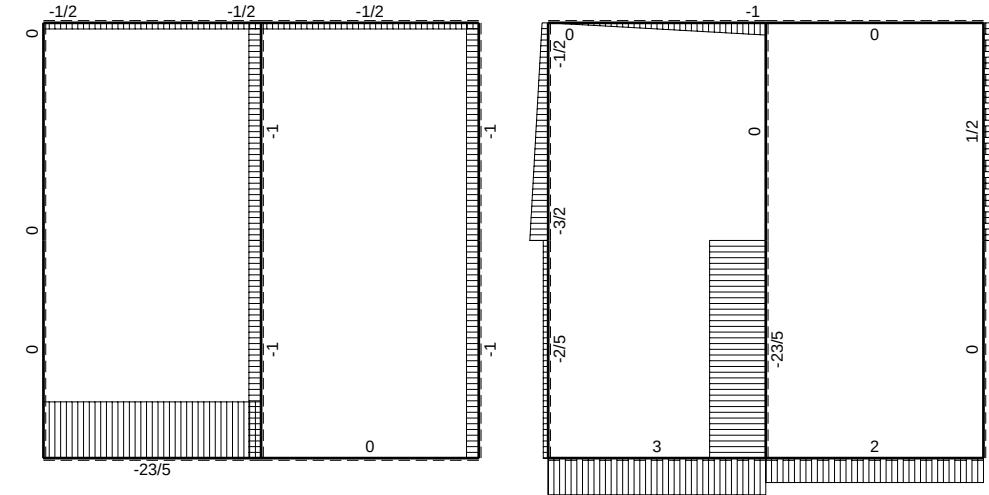
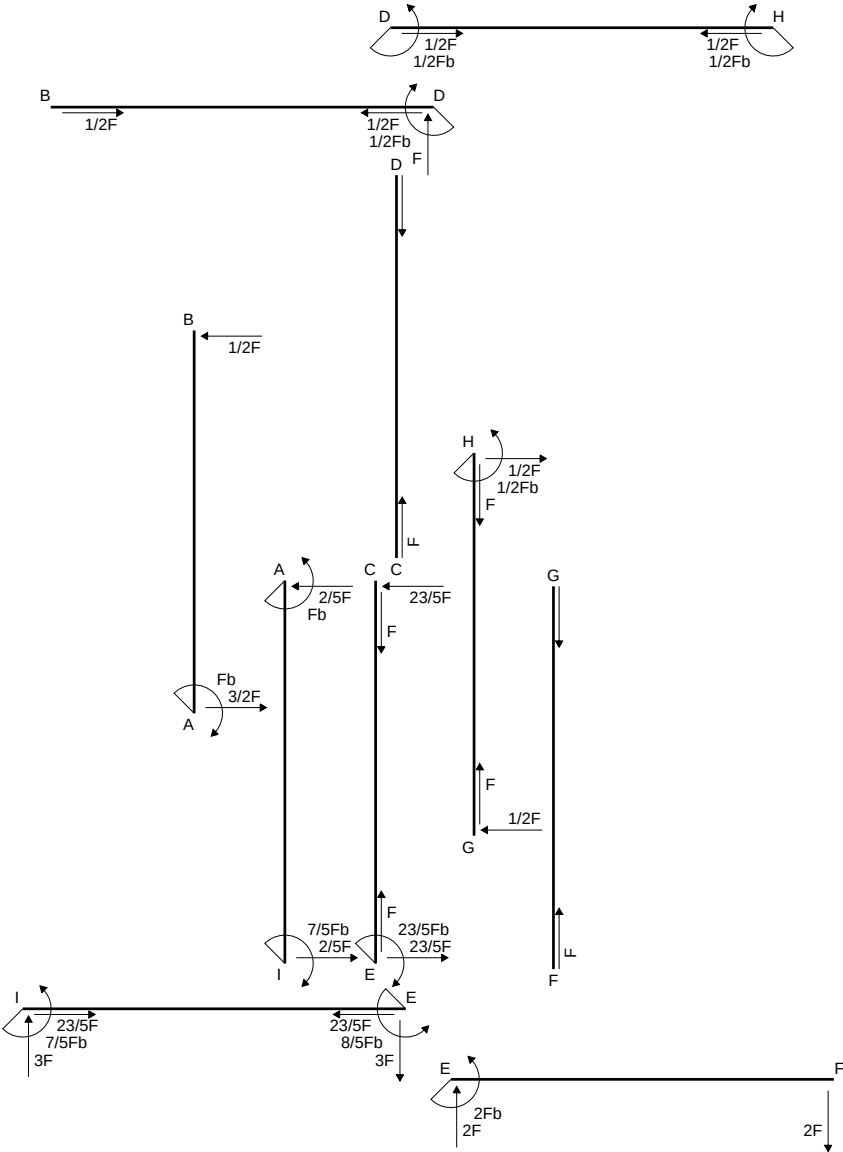
$$v_c = -24.53 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -163.9 \text{ N/mm}^2$$

$$\tau_c = 4.277 \text{ N/mm}^2$$

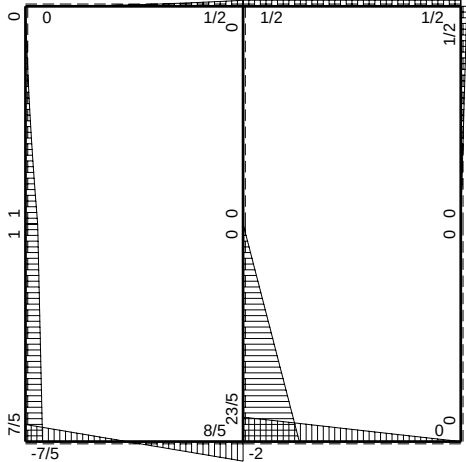
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 164.1 \text{ N/mm}^2$$

$$S = 3495. \text{ mm}^3$$

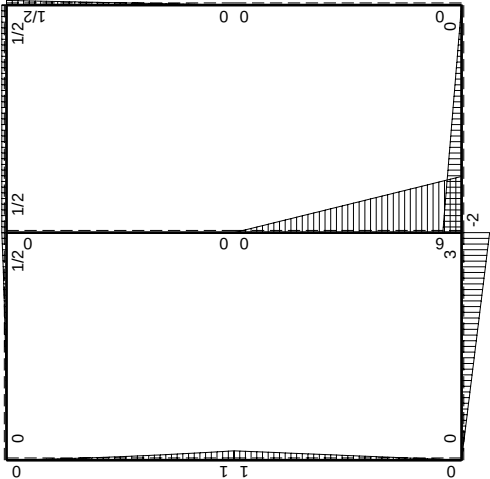
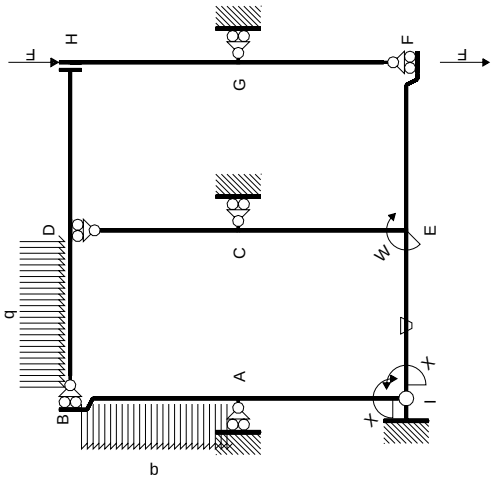


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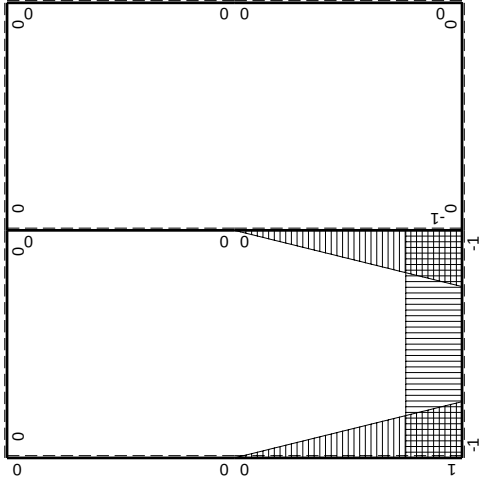


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

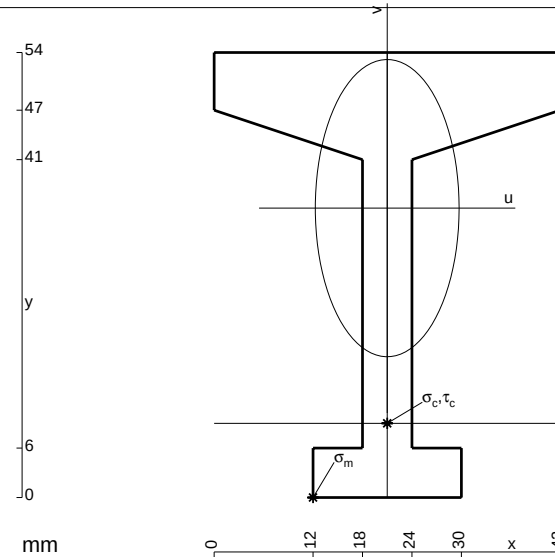
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 756. \text{ mm}^2$$

$$J_u = 245989. \text{ mm}^4$$

$$J_v = 57564. \text{ mm}^4$$

$$y_g = 35.12 \text{ mm}$$

$$T_y = 1660. \text{ N}$$

$$M_x = -1610200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -35.12 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

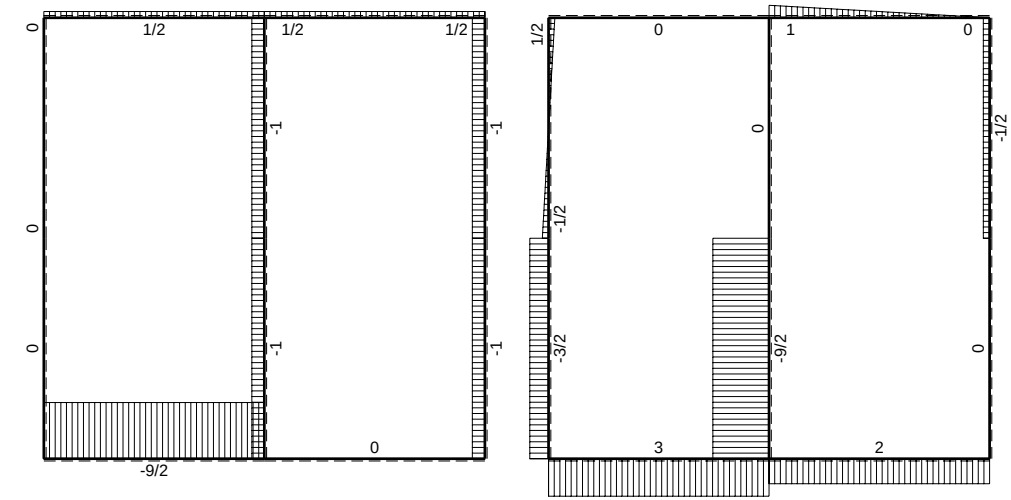
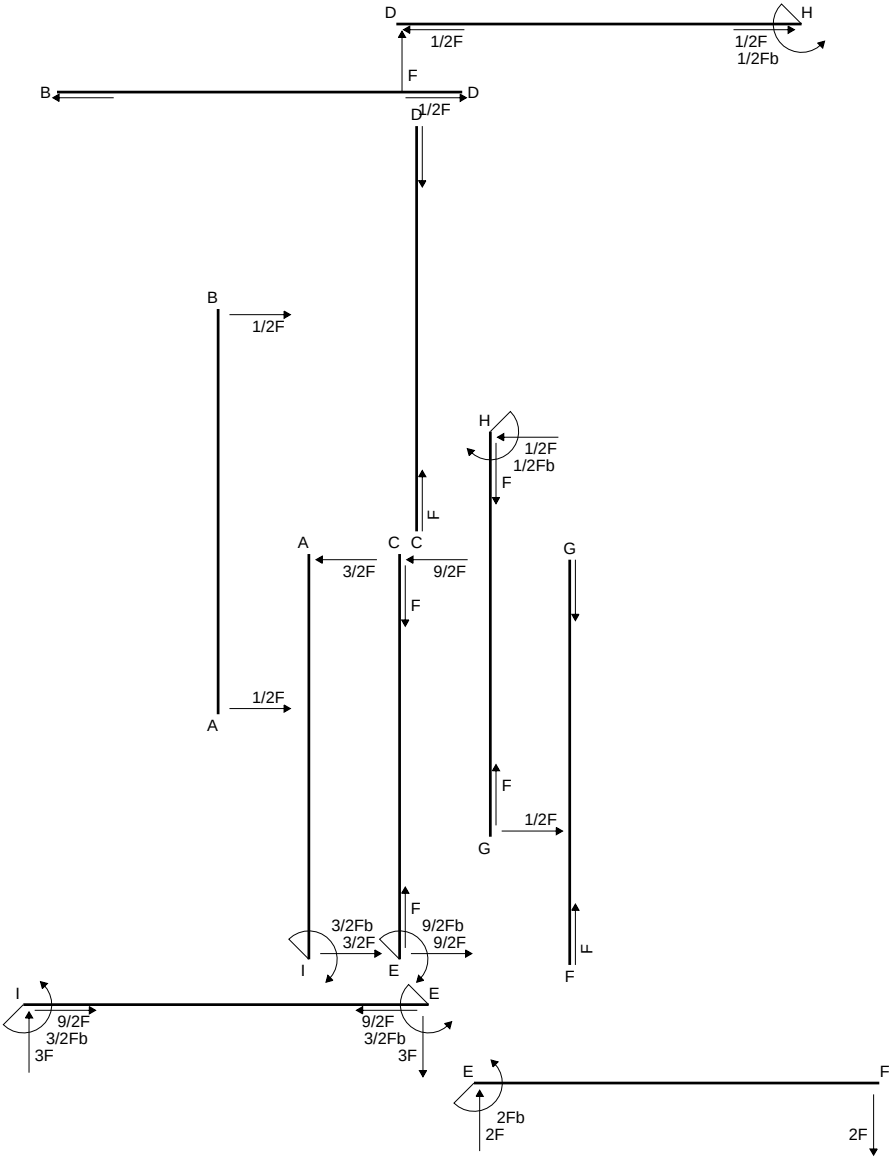
$$v_c = -26.12 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -171. \text{ N/mm}^2$$

$$\tau_c = 4.461 \text{ N/mm}^2$$

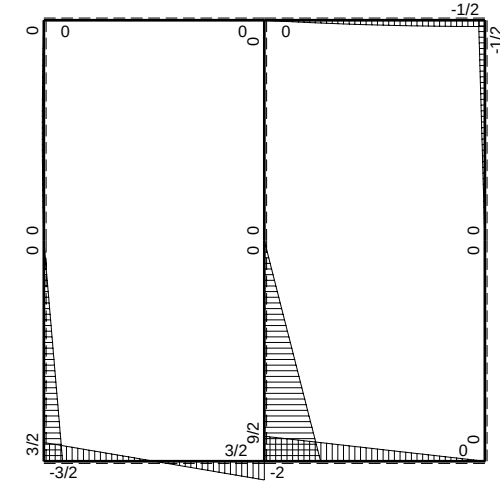
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 171.1 \text{ N/mm}^2$$

$$S = 3966. \text{ mm}^3$$



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⊕ ⊕ Fb

Quadro contributi PLV per iperstatica X=W_{IE}

→	M _x (x)	M _o (x)	θ	M _x M _o	M _x θ	M _x M _x	∫M _x (M _o /EJ+θ)dx	∫XM _x M _x /EJdx
AB b	0	-1/2Fx+1/2qx ²	0	0	0	0	0+0	0
BA b	0	1/2Fx-1/2qx ²	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-1/2Fx	0	0	0	0	0+0	0
HG b	0	1/2Fb-1/2Fx	0	0	0	0		
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0
DH b	0	Fx-1/2qx ²	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	-1+x/b	6Fb-6Fx	0	-6Fb+12Fx-6Fx ² /b	0	1-2x/b+x ² /b ²	(-2+0)Fb ² /EJ	1/3Xb/EJ
CE b	x/b	-6Fx	0	-6Fx ² /b	0	x ² /b ²		
IA b	1-x/b	0	0	0	0	1-2x/b+x ² /b ²	0+0	1/3Xb/EJ
AI b	-x/b	0	0	0	0	x ² /b ²		
	totali						-5/2Fb ² /EJ	5/3Xb/EJ
	iperstatica X=W _{IE}						3/2Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

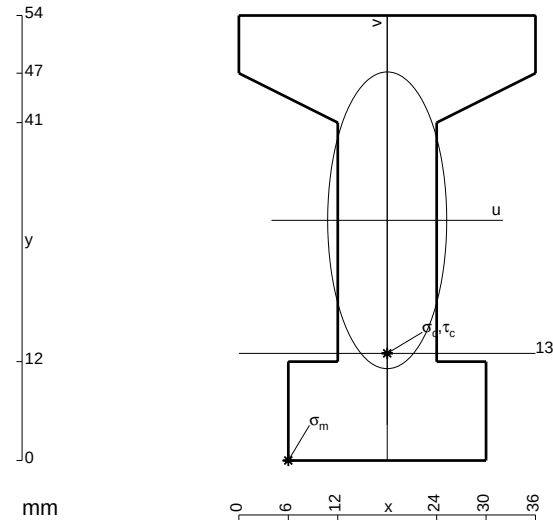
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$



$$A = 1032. \text{ mm}^2$$

$$J_u = 334856. \text{ mm}^4$$

$$J_v = 53856. \text{ mm}^4$$

$$y_g = 29.15 \text{ mm}$$

$$T_y = 2700. \text{ N}$$

$$M_x = -2754000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.15 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.8 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

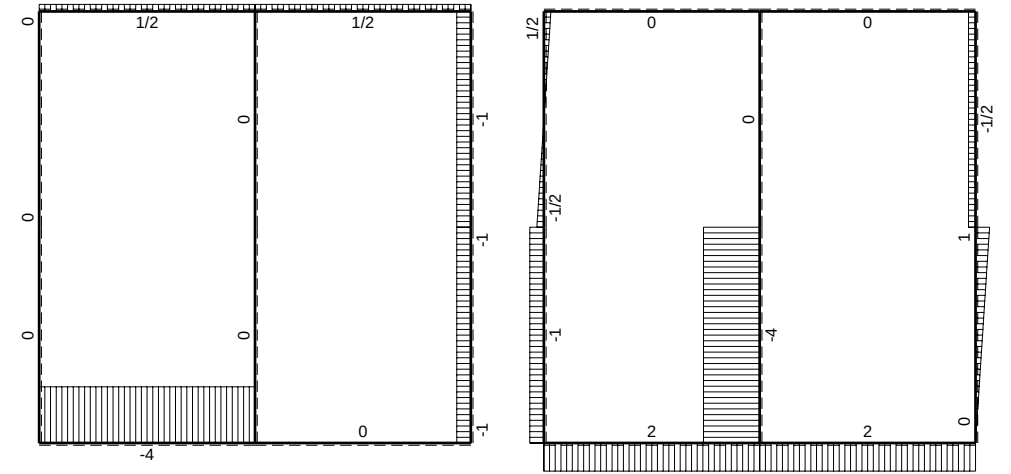
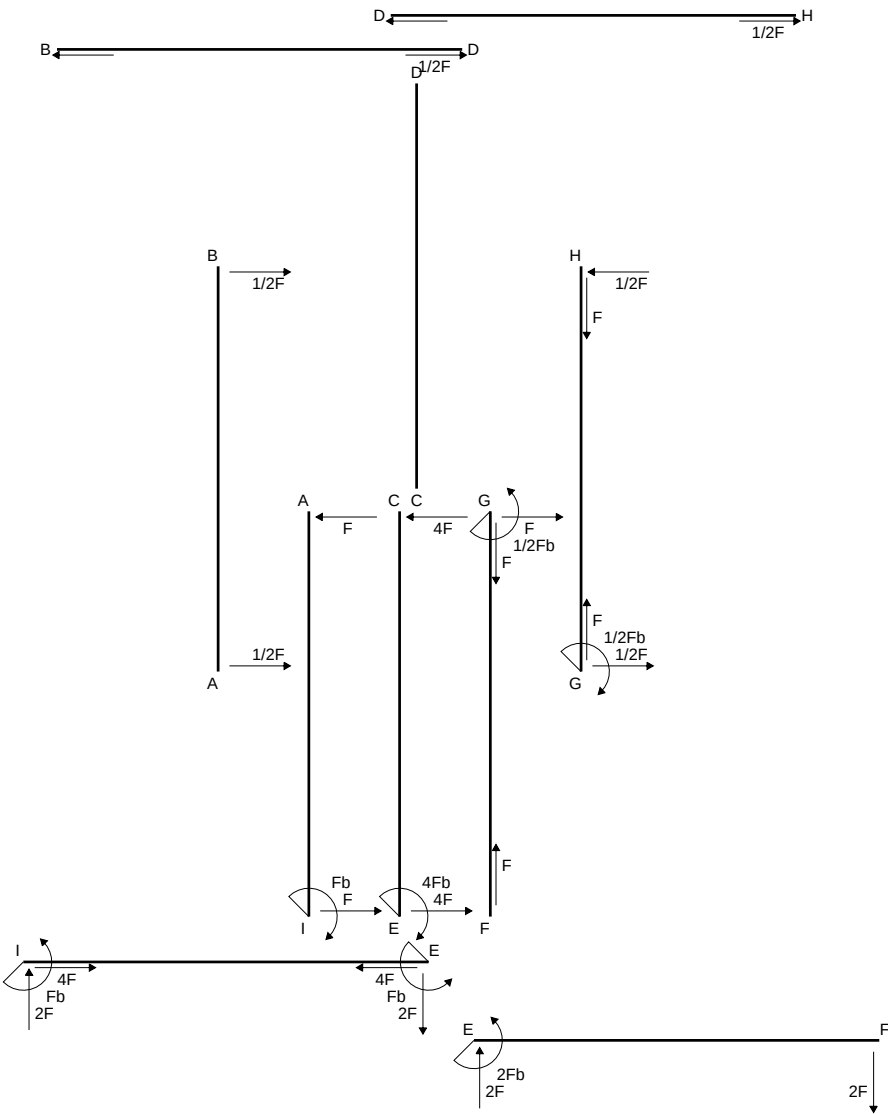
$$v_c = -16.15 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -132.8 \text{ N/mm}^2$$

$$\tau_c = 4.614 \text{ N/mm}^2$$

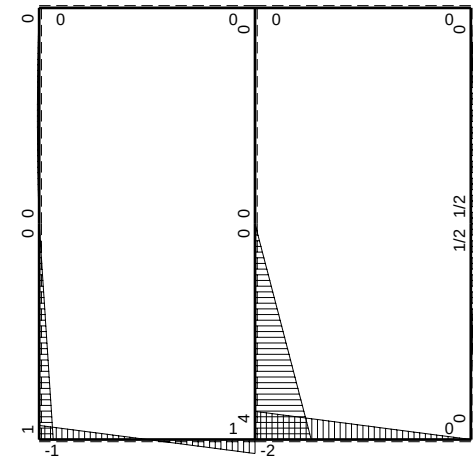
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 133.1 \text{ N/mm}^2$$

$$S = 6867. \text{ mm}^3$$

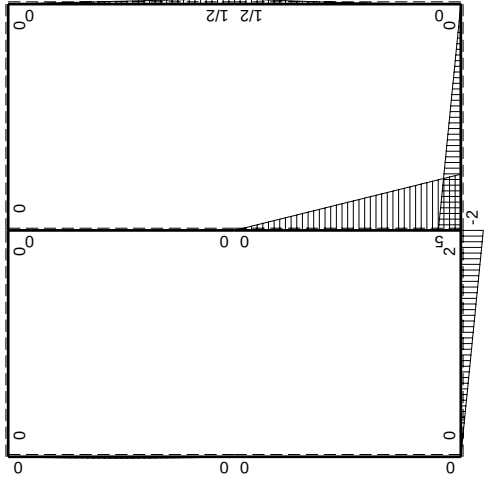
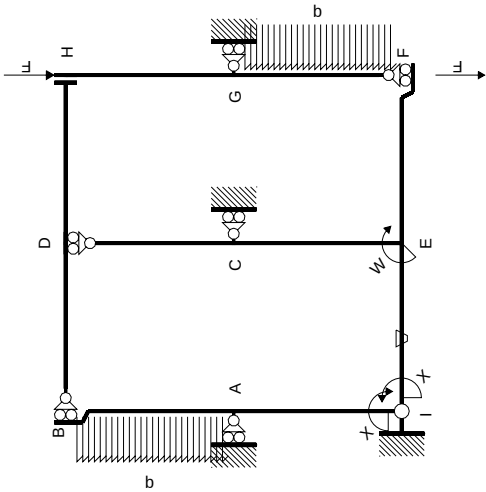


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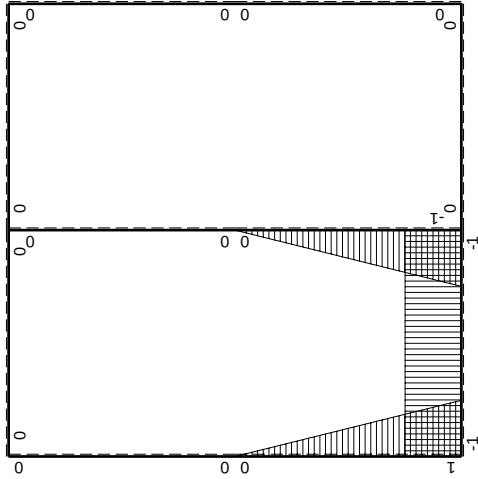


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{XX} = \int_0^b (1) \cdot 1/EJ \, dx = \left[x \right]_0^b \cdot 1/EJ$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \cdot 1/EJ \, dx = \left[x \right]_0^b \cdot 1/EJ$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + \frac{1}{3} b) \frac{1}{EJ} = \frac{1}{3} \frac{b}{EJ}$$

$$L_{CE}^{xx} = \int_0^b \left(x^2/b^2 \right) 1/EJ \, dx = \left[1/3 x^3/b^2 \right]_0^b 1/EJ$$

$$= (1/3 b) \cdot 1/EJ = 1/3 \cdot b/EJ$$

$$L_{IA}^{XX} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + \frac{1}{3}b) \frac{1}{EJ} = \frac{1}{3} \frac{b}{EJ}$$

$$L_{AI}^{XX} = \int_0^b (x^2/b^2) \cdot 1/EJ \, dx = \left[1/3 x^3/b^2 \right]_0^b \cdot 1/EJ$$

$$= (1/3 b) \cdot 1/EJ = 1/3 \cdot b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb/EJ \, dx + \int_0^b (1) \theta \, dx = \left[-x^2/b \right]_0^b Fb/EJ + \left[x \right]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb \, 1/EJ \, dx + \int_0^b (-1) \theta \, dx = \left[-2x + x^2/b \right]_0^b Fb \, 1/EJ + \left[-x \right]_0^b \theta$$

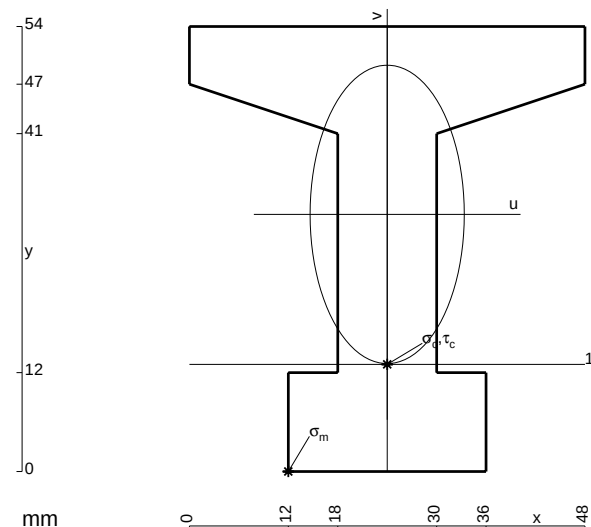
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10 x/b - 5 x^2/b^2) F_b 1/EJ dx = [-5 x + 5 x^2/b - 5/3 x^3/b^2]_0^b F_b 1/EJ$$

$$= (-5b + 5b - 5/3b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{X_0} = \int_0^b (-5 x^2/b^2) Fb \, 1/EJ \, dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \, 1/EJ$$

$$= \left(-\frac{5}{3} b \right) Fb \frac{1}{EJ} = -\frac{5}{3} \frac{Fb^2}{EJ}$$



$$A = 1152. \text{ mm}^2$$

$$J_x = 377748. \text{ mm}^4$$

$$J_v = 100872. \text{ mm}^4$$

$$y_g = 31.2 \text{ mm}$$

$$T_y = 4480. \text{ N}$$

$$M_x = -2419200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -31.2 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

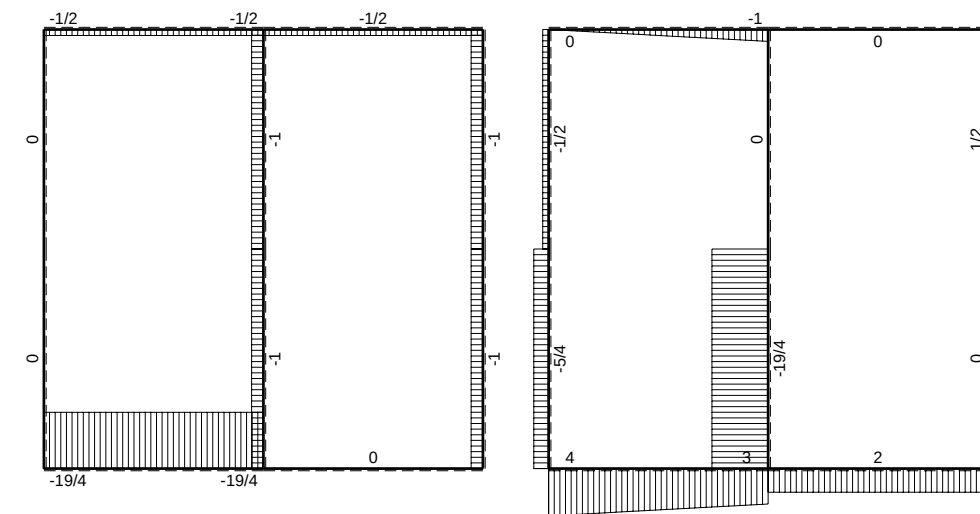
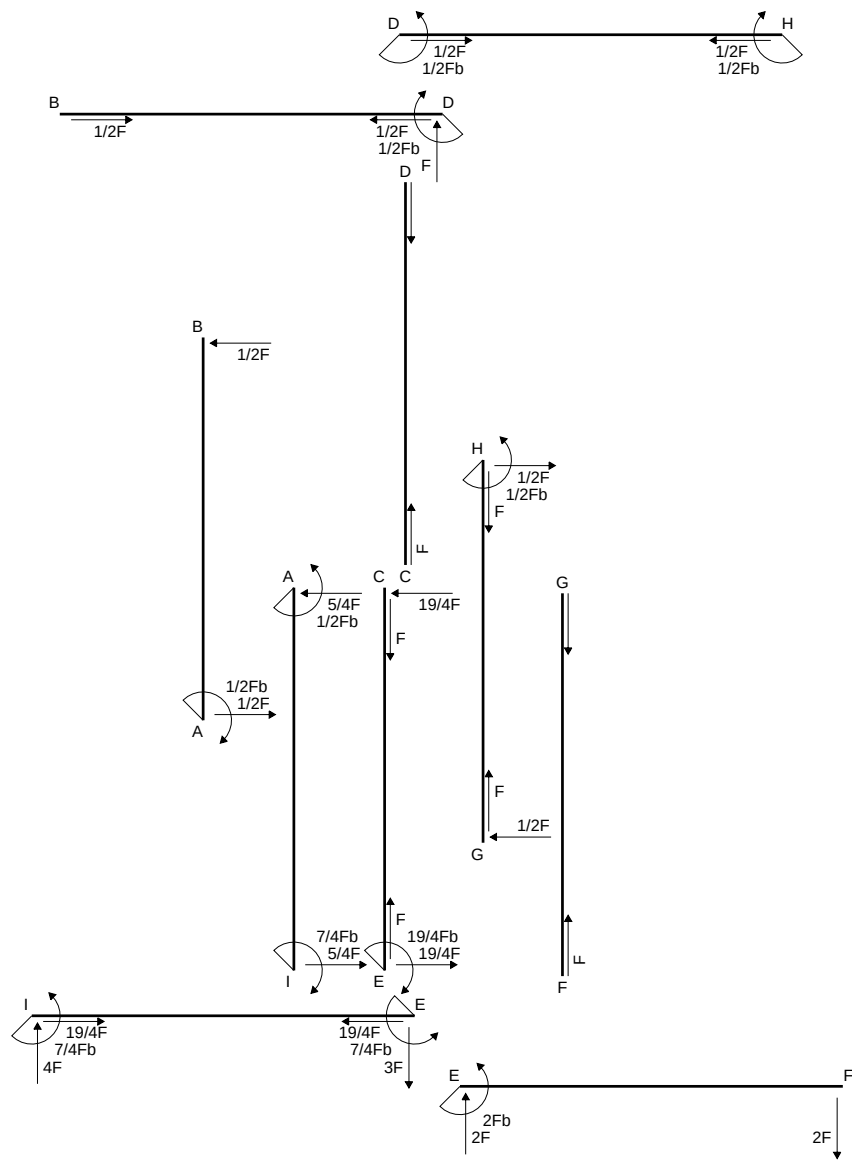
$$V_c = -18.2 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -116.6 \text{ N/mm}^2$$

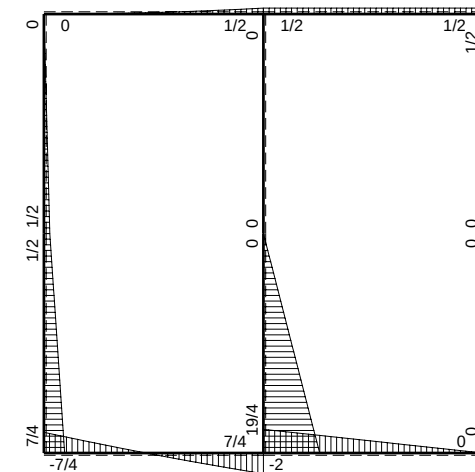
$$\tau_c = 7.395 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma + 3\tau} = 117.3 \text{ N/mm}^2$$

$$S = 7483. \text{ mm}$$


$$\leftarrow \boxed{+} \rightarrow_F$$

$\uparrow \boxed{+} \downarrow F$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

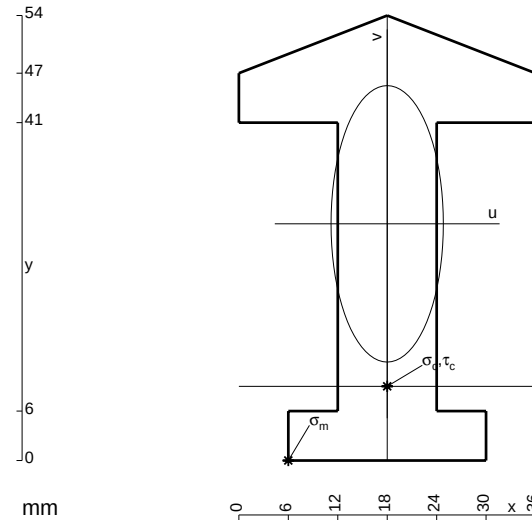
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 906. \text{ mm}^2$$

$$J_u = 254971. \text{ mm}^4$$

$$J_v = 42084. \text{ mm}^4$$

$$y_g = 28.72 \text{ mm}$$

$$T_y = 3140. \text{ N}$$

$$M_x = -1852600. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.72 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.7 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

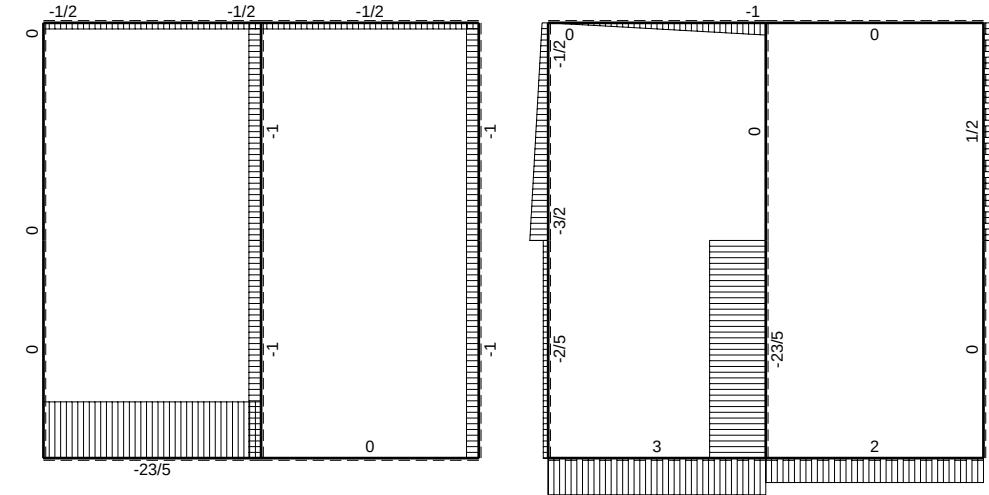
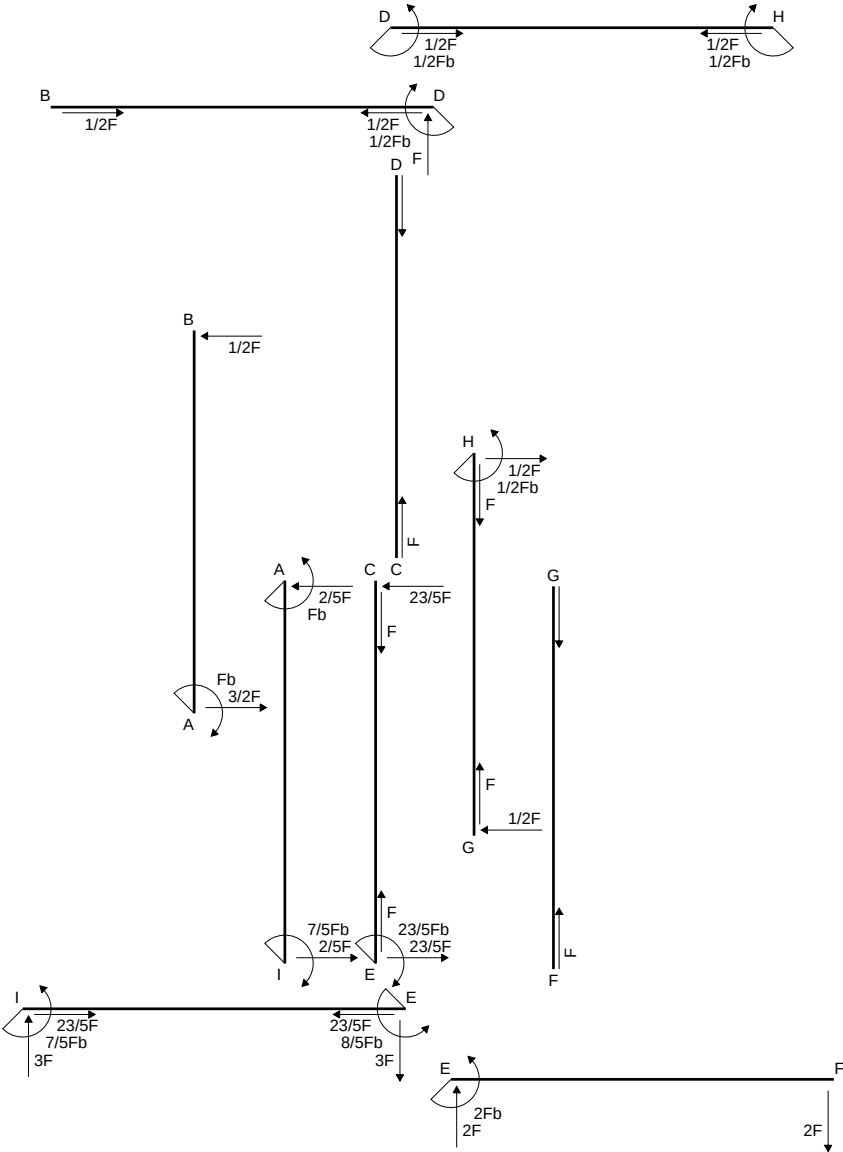
$$v_c = -19.72 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -143.3 \text{ N/mm}^2$$

$$\tau_c = 4.585 \text{ N/mm}^2$$

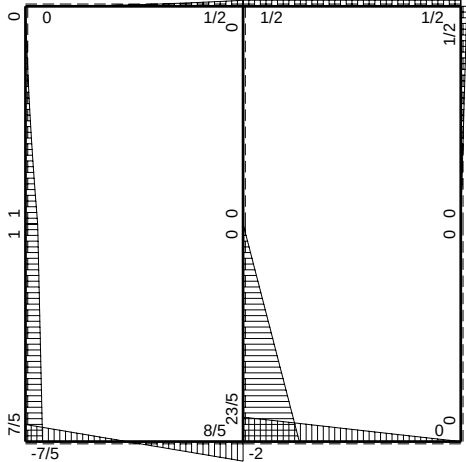
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 143.5 \text{ N/mm}^2$$

$$S = 4468. \text{ mm}^3$$

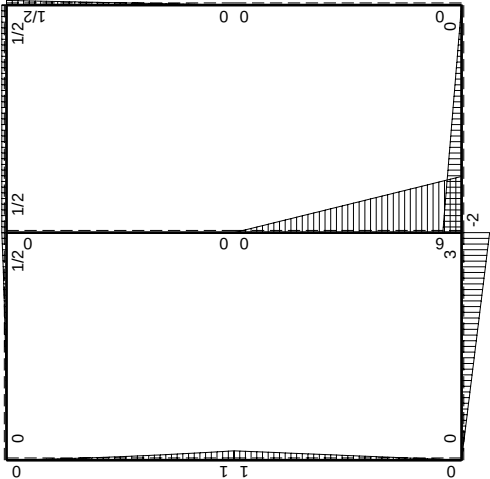
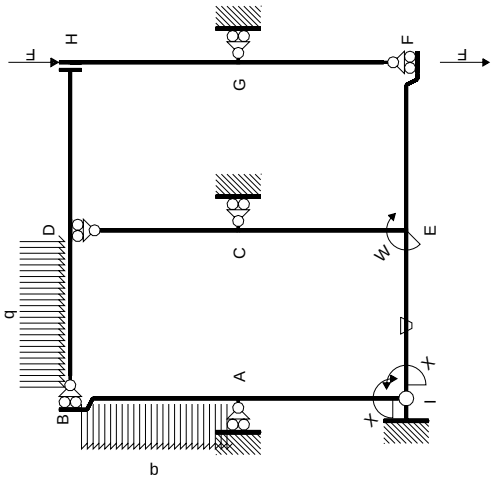


← ⊕ → F

↑ ⊕ ↓ Fb

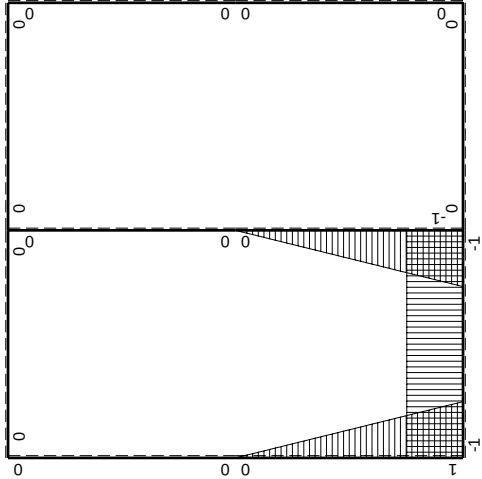


⊕ ⊖ Fb



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

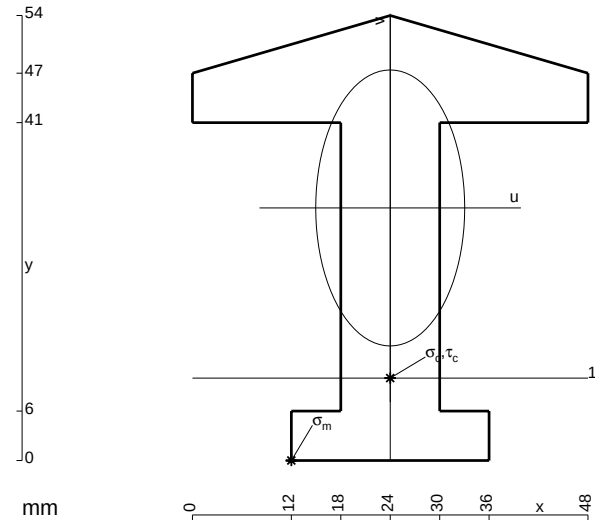
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 1020. \text{ mm}^2$$

$$J_u = 286162. \text{ mm}^4$$

$$J_v = 83376. \text{ mm}^4$$

$$y_g = 30.65 \text{ mm}$$

$$T_y = 3200. \text{ N}$$

$$M_x = -2048000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.65 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.3 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

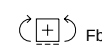
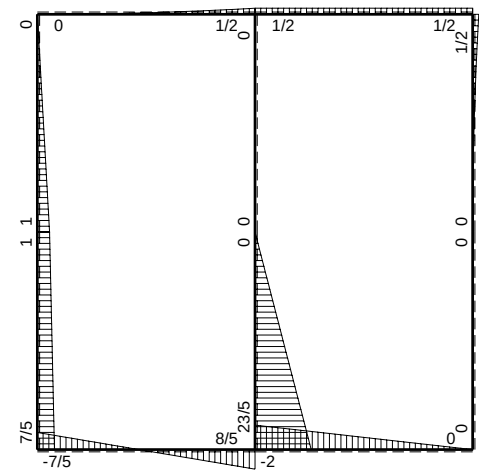
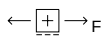
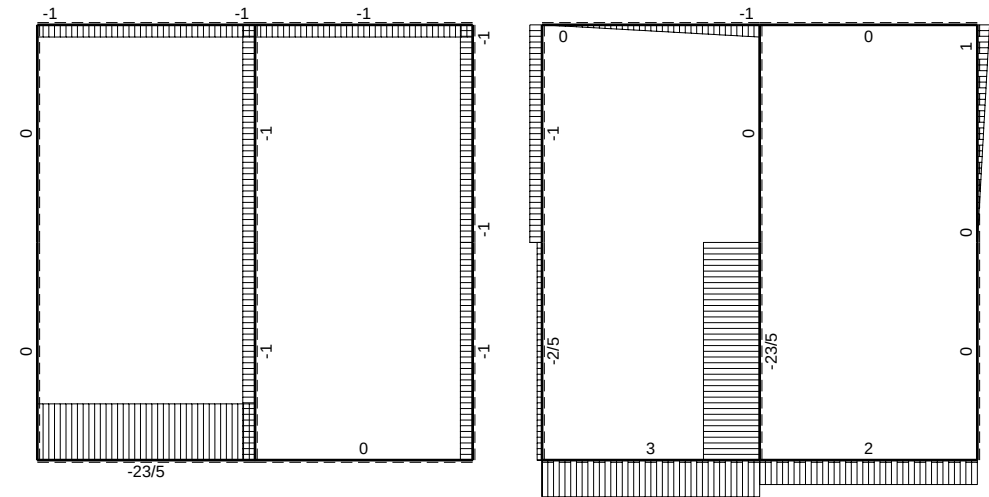
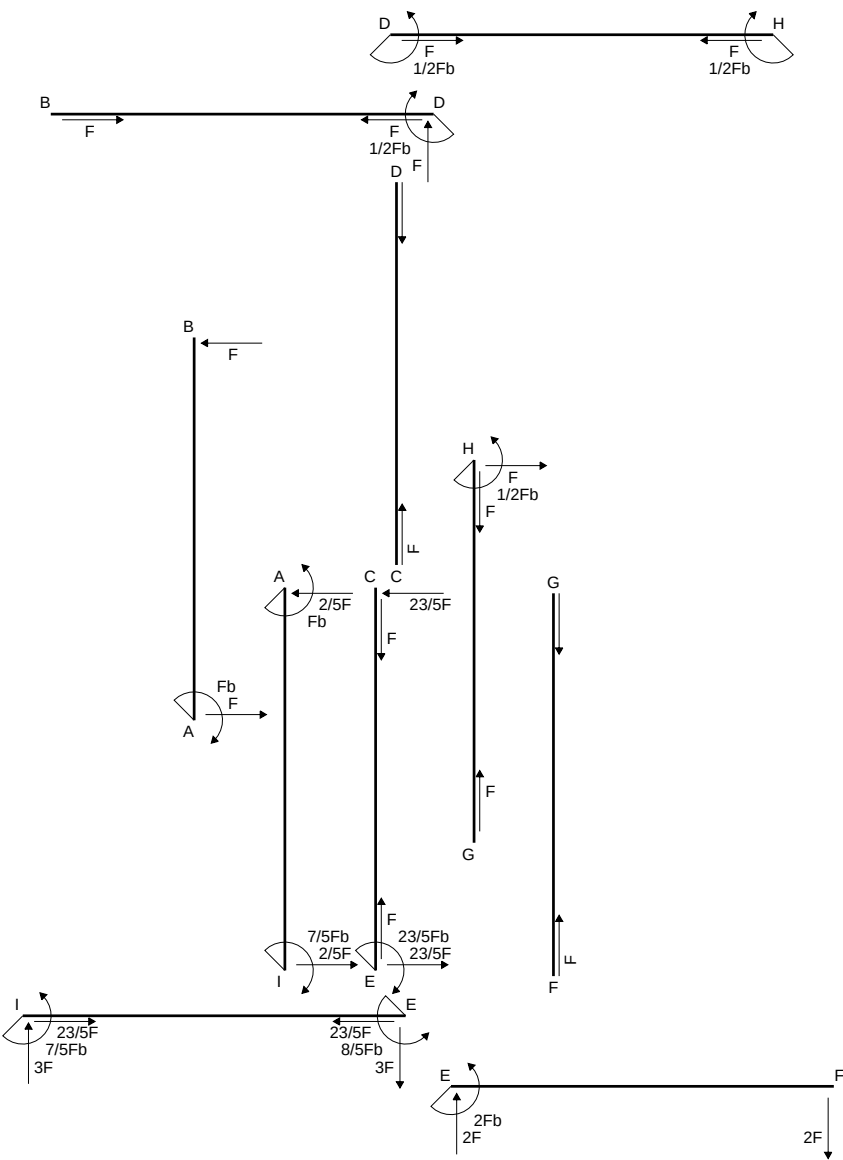
$$v_c = -20.65 \text{ mm}$$

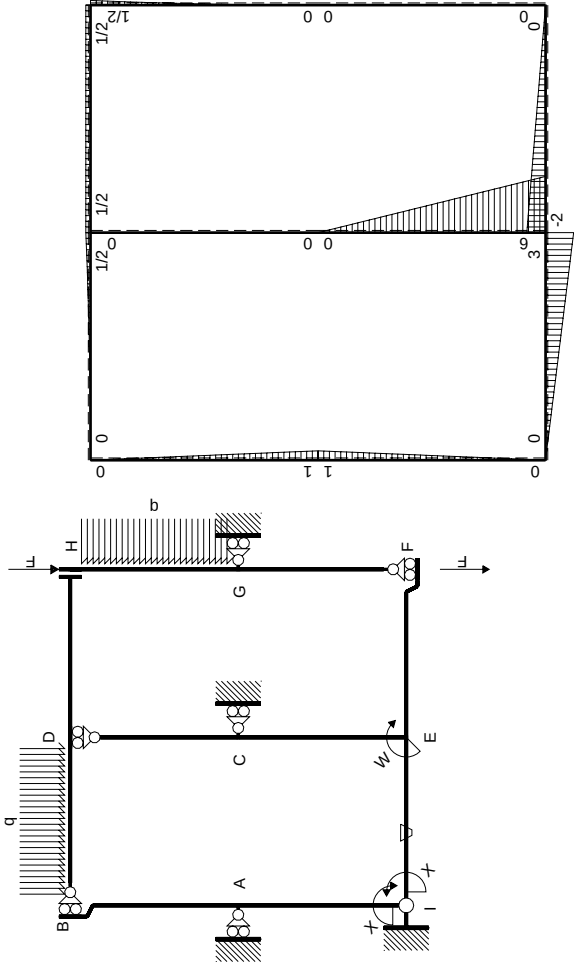
$$\sigma_c = -Mv/J_u = -147.8 \text{ N/mm}^2$$

$$\tau_c = 4.723 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 148. \text{ N/mm}^2$$

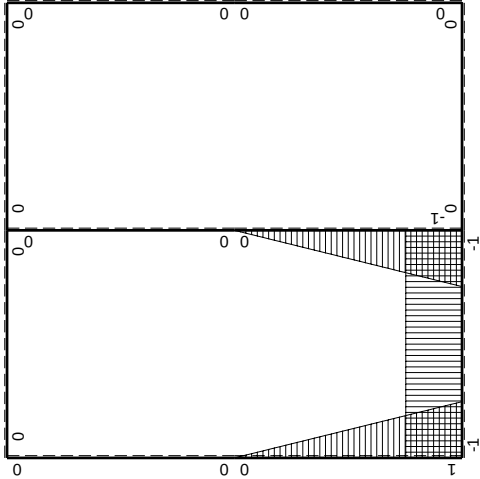
$$S^* = 5069. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-Fx$	0	0	0	0	0+0	0
BA b	0	$-Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

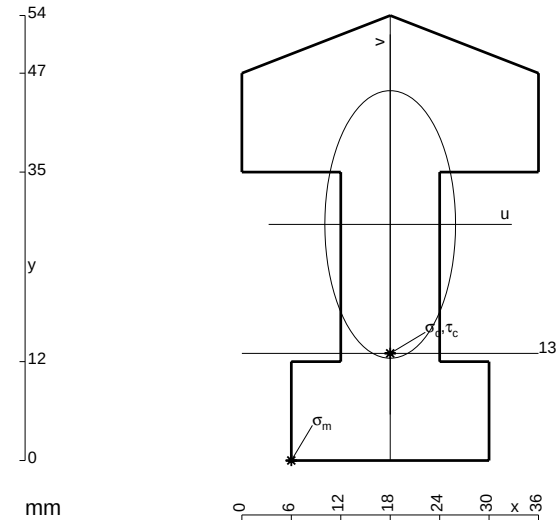
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 1122. \text{ mm}^2$$

$$J_u = 296013. \text{ mm}^4$$

$$J_v = 70596. \text{ mm}^4$$

$$y_g = 28.65 \text{ mm}$$

$$T_y = 3380. \text{ N}$$

$$M_x = -2366000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.65 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229. \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

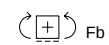
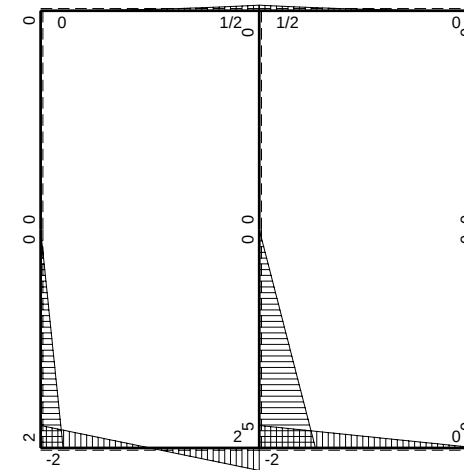
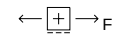
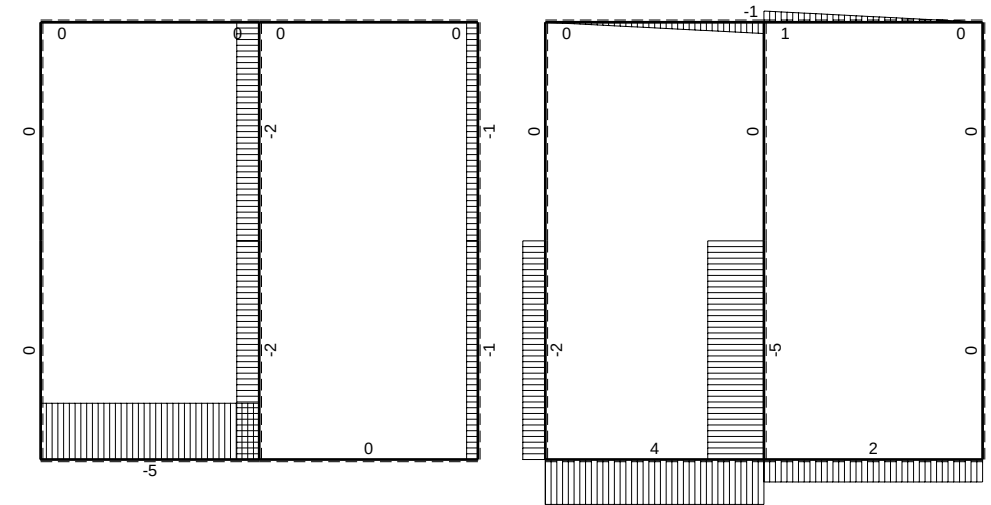
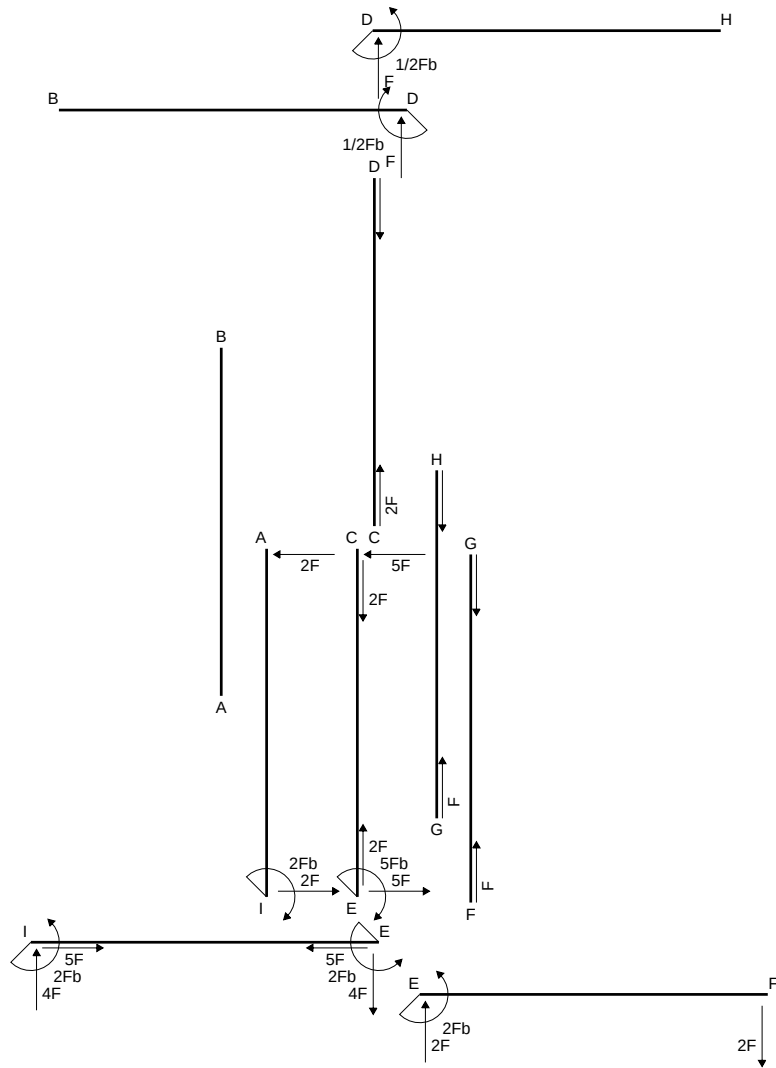
$$v_c = -15.65 \text{ mm}$$

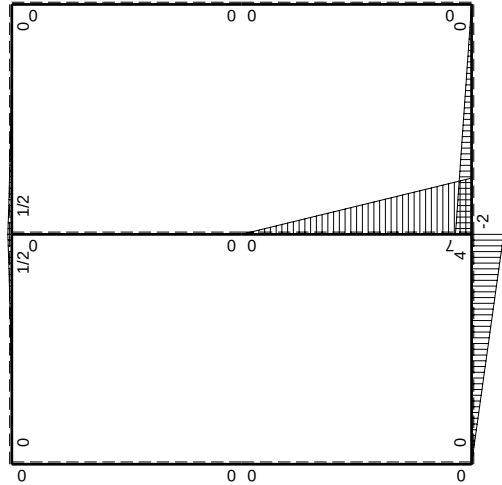
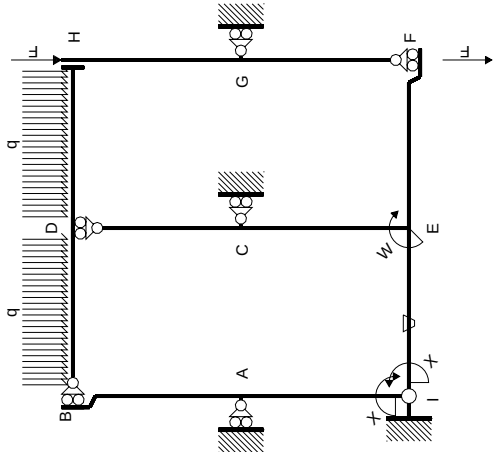
$$\sigma_c = -Mv/J_u = -125.1 \text{ N/mm}^2$$

$$\tau_c = 6.391 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 125.6 \text{ N/mm}^2$$

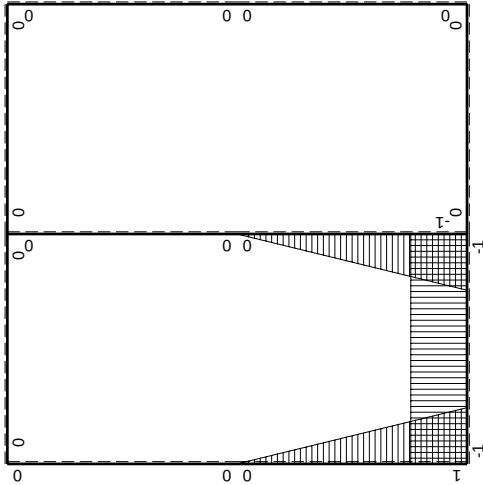
$$S = 6716. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$7Fb-7Fx$	0	$-7Fb+14Fx-7Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-7Fx$	0	$-7Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-10/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						2Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

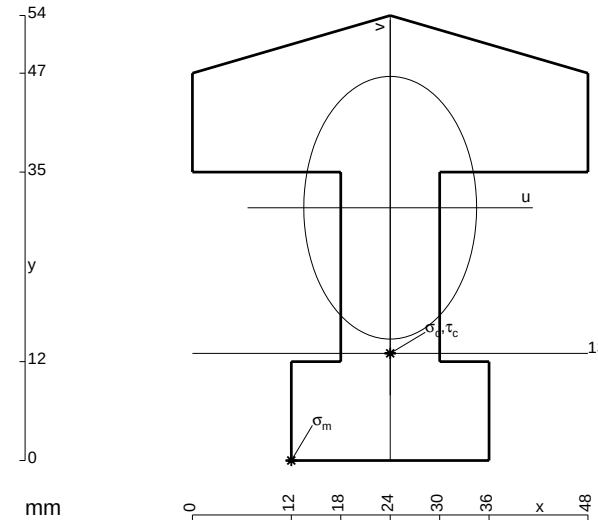
$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-7 + 14x/b - 7x^2/b^2) Fb \frac{1}{EJ} dx = \left[-7x + 7x^2/b - 7/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

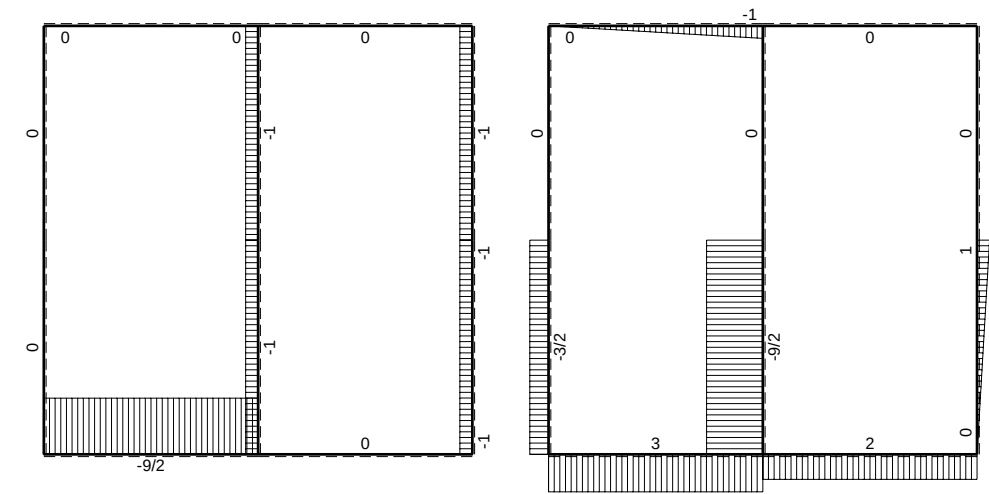
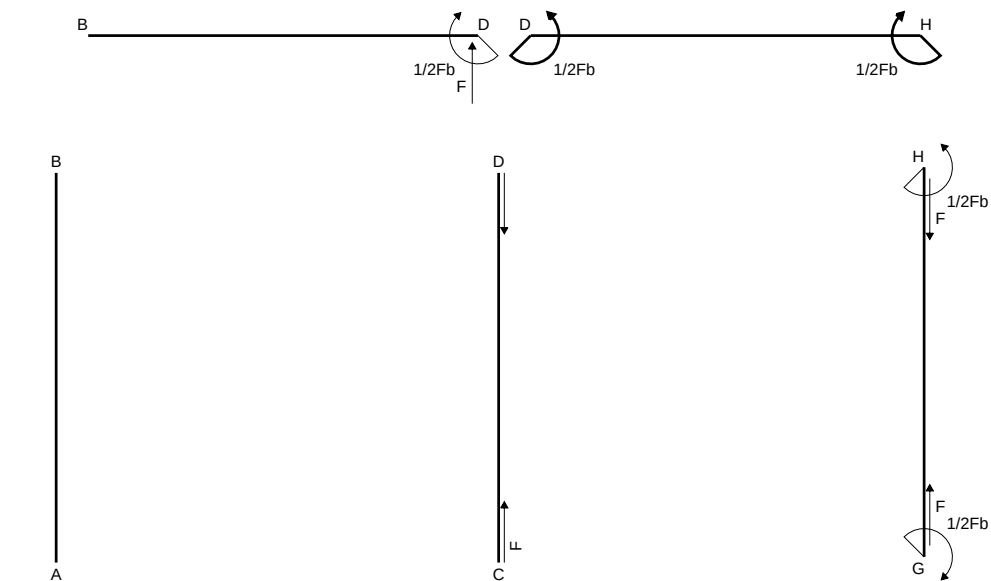
$$= (-7b + 7b - 7/3 b) Fb \frac{1}{EJ} = -7/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7x^2/b^2) Fb \frac{1}{EJ} dx = \left[-7/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-7/3 b) Fb \frac{1}{EJ} = -7/3 Fb^2/EJ$$

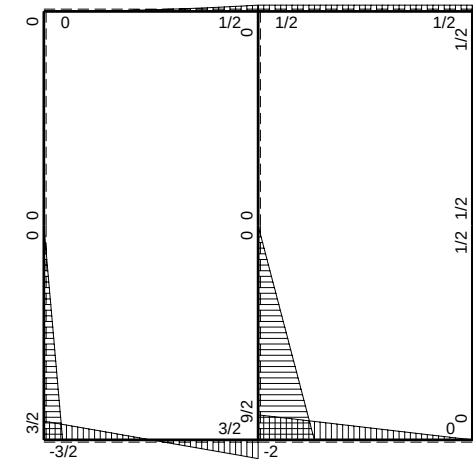
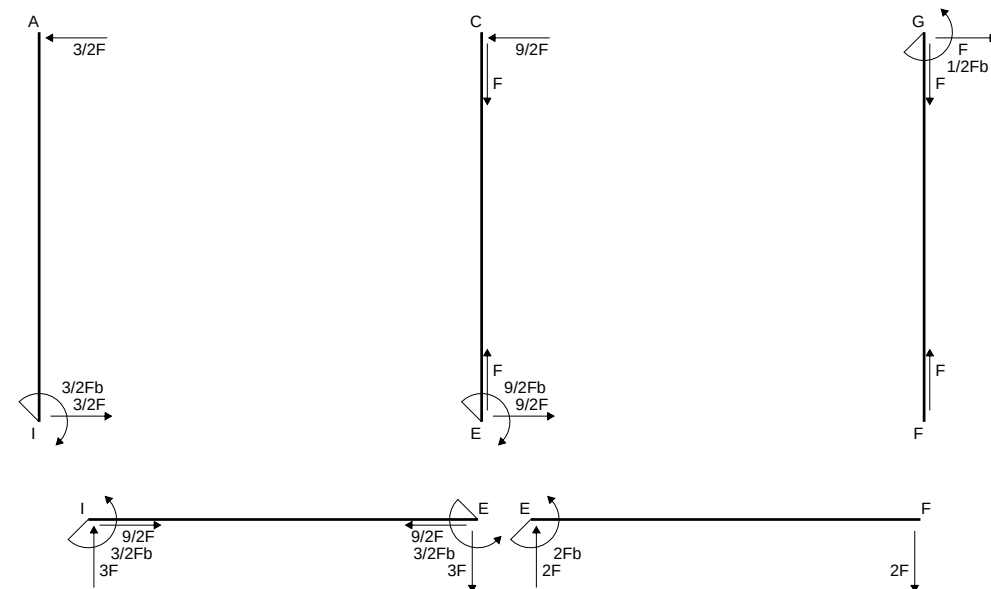


$$\begin{aligned} A &= 1308. \text{ mm}^2 \\ J_u &= 332443. \text{ mm}^4 \\ J_v &= 143856. \text{ mm}^4 \\ y_g &= 30.67 \text{ mm} \\ T_y &= 3460. \text{ N} \\ M_x &= -2595000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.67 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 13. \text{ mm} \\ v_c &= -17.67 \text{ mm} \\ \sigma_c &= -Mv/J_u = -137.9 \text{ N/mm}^2 \\ \tau_c &= 6.352 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 138.4 \text{ N/mm}^2 \\ S &= 7323. \text{ mm}^3 \end{aligned}$$

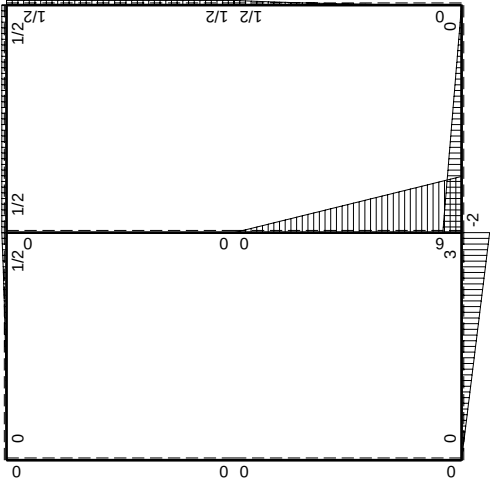
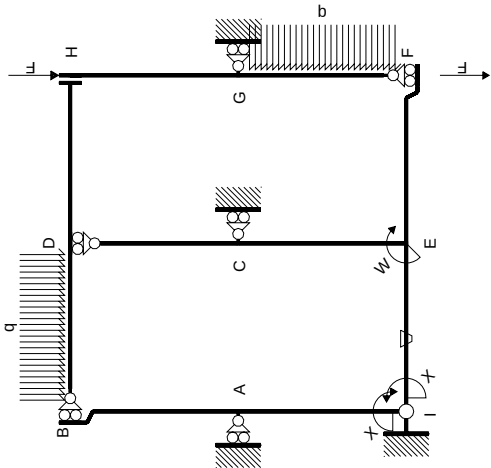


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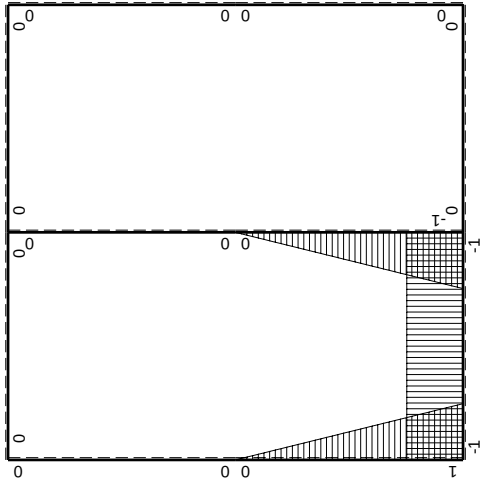


⊕ ⊖ Fb



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

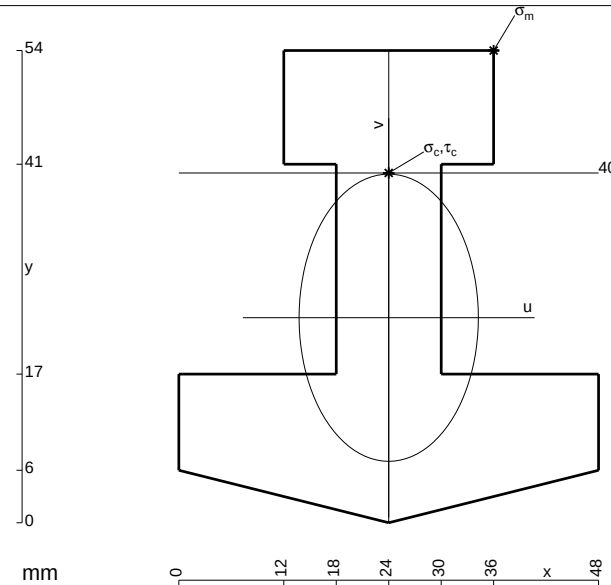
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

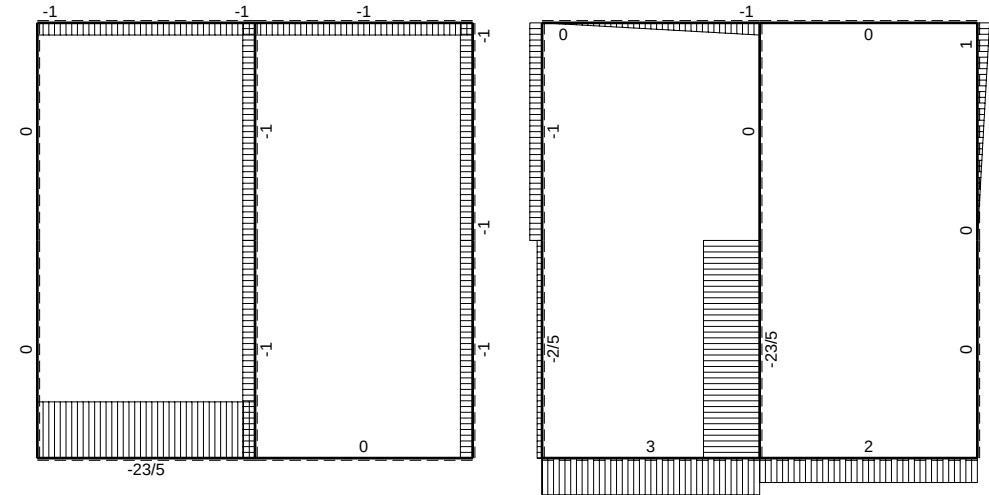
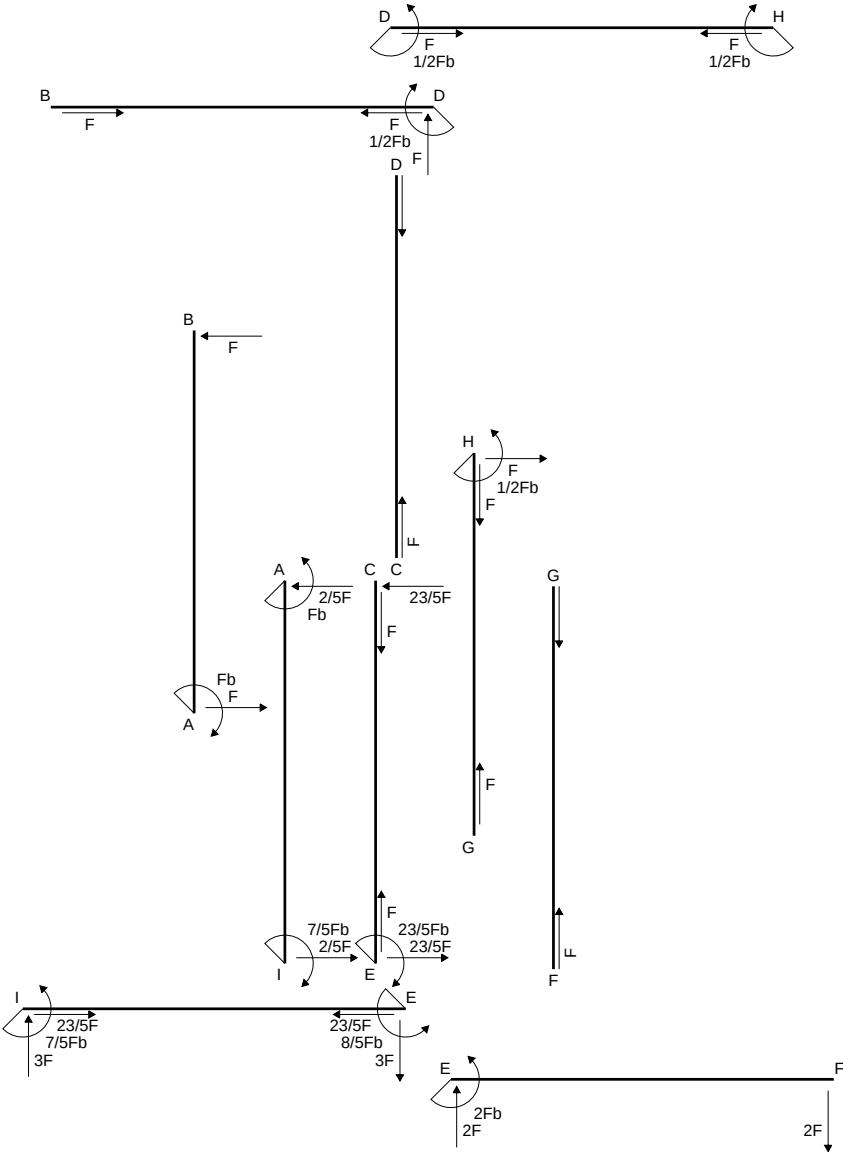
$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

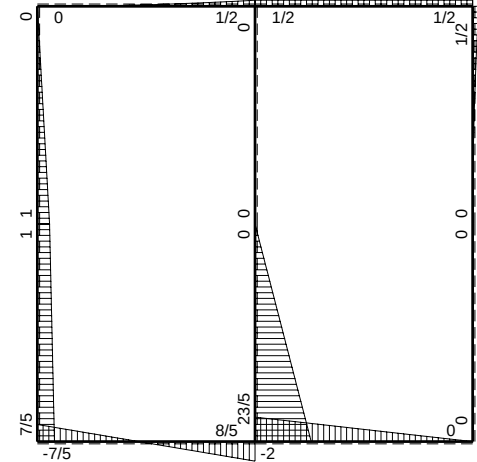


$$\begin{aligned} A &= 1272. \text{ mm}^2 \\ J_u &= 343038. \text{ mm}^4 \\ J_v &= 133632. \text{ mm}^4 \\ y_g &= 23.44 \text{ mm} \\ T_y &= 2760. \text{ N} \\ M_x &= -2235600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.56 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.1 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 16.56 \text{ mm} \\ \sigma_c &= -Mv/J_u = 107.9 \text{ N/mm}^2 \\ \tau_c &= 5.17 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 108.3 \text{ N/mm}^2 \\ S &= 7710. \text{ mm}^3 \end{aligned}$$

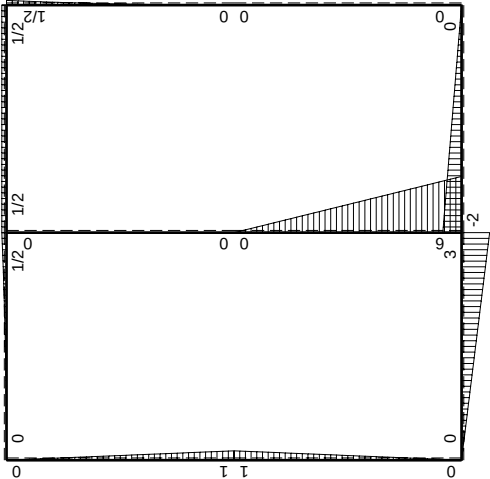
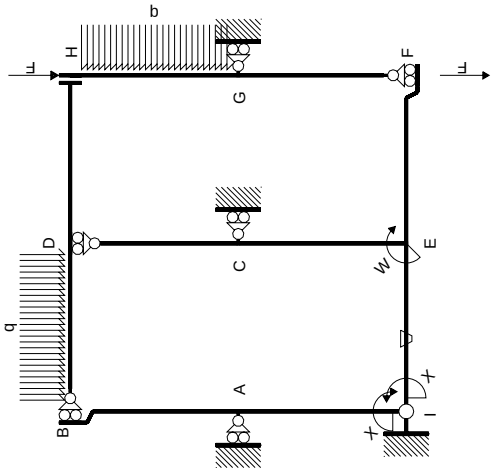


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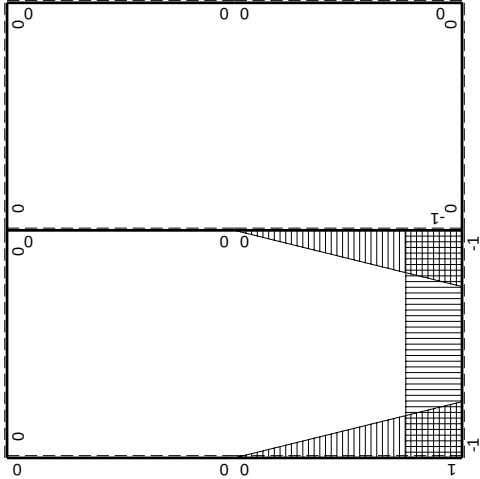


← $\boxed{+}$ → F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-Fx$	0	0	0	0	0+0	0
BA b	0	$-Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

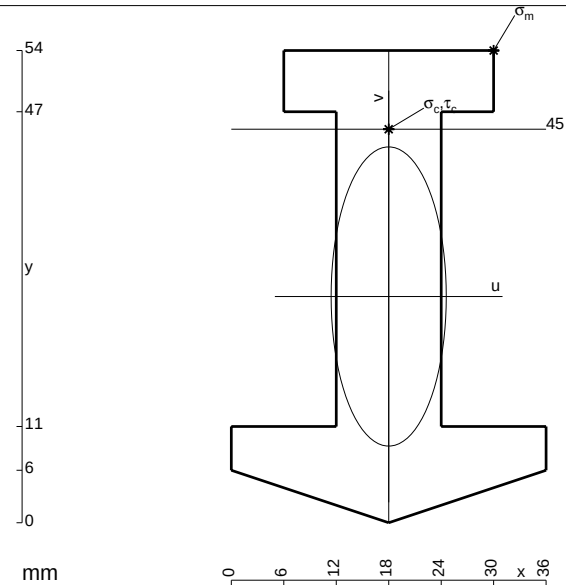
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 888. \text{ mm}^2$$

$$J_u = 260045. \text{ mm}^4$$

$$J_v = 38520. \text{ mm}^4$$

$$y_g = 25.87 \text{ mm}$$

$$T_y = 2240. \text{ N}$$

$$M_x = -1926400. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.13 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.4 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 45. \text{ mm}$$

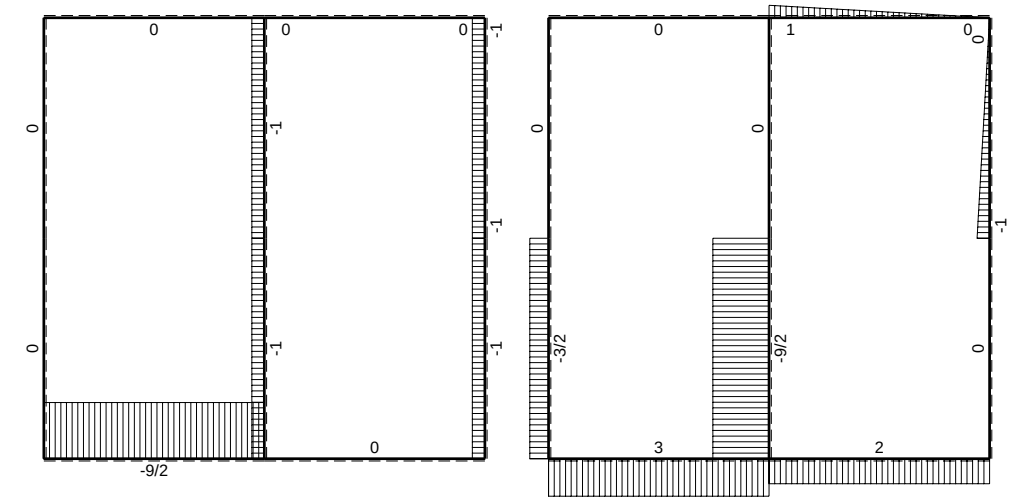
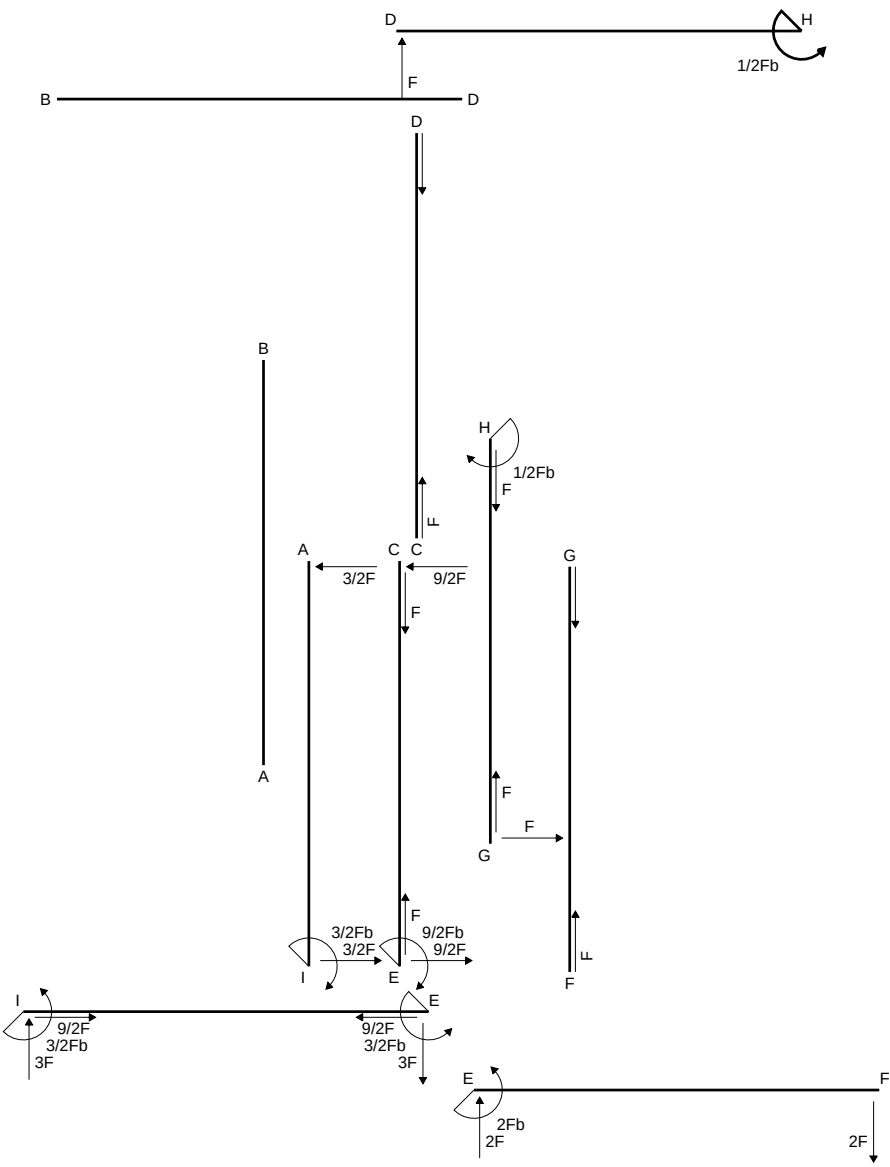
$$v_c = 19.13 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 141.7 \text{ N/mm}^2$$

$$\tau_c = 3.317 \text{ N/mm}^2$$

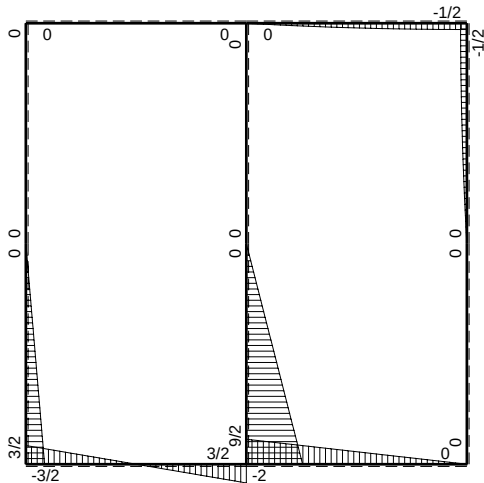
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 141.8 \text{ N/mm}^2$$

$$S = 4621. \text{ mm}^3$$

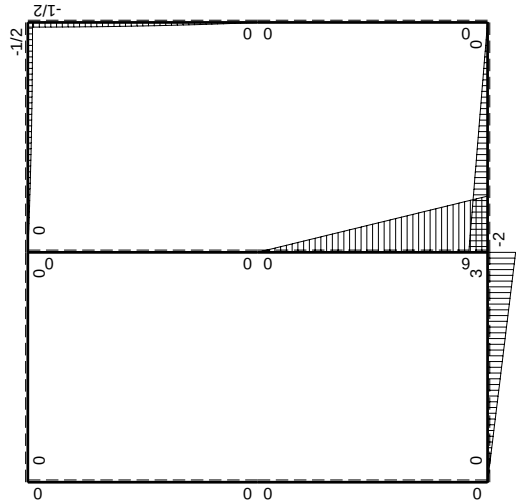
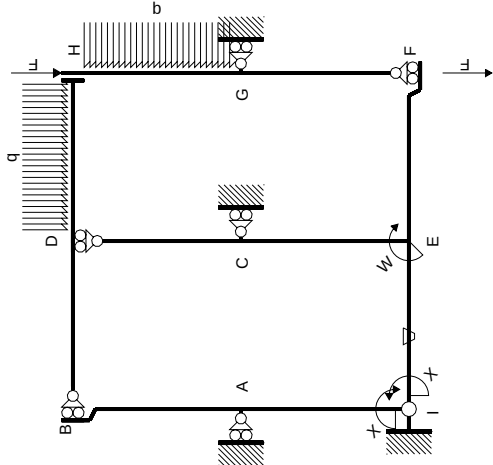


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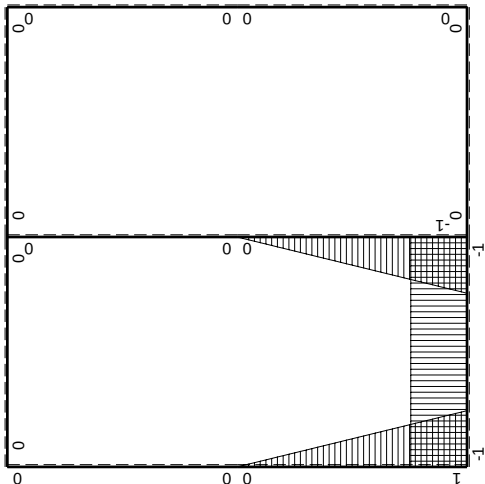


⊕ ⊖ Fb



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica X=W_{IE}

→	M _x (x)	M _o (x)	θ	M _x M _o	M _x θ	M _x M _x	∫M _x (M _o /EJ+θ)dx	∫XM _x M _x /EJdx
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-Fx+1/2qx ²	0	0	0	0	0+0	0
HG b	0	1/2Fb-1/2qx ²	0	0	0	0		
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0
DH b	0	Fx-1/2qx ²	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	-1+x/b	6Fb-6Fx	0	-6Fb+12Fx-6Fx ² /b	0	1-2x/b+x ² /b ²	(-2+0)Fb ² /EJ	1/3Xb/EJ
CE b	x/b	-6Fx	0	-6Fx ² /b	0	x ² /b ²		
IA b	1-x/b	0	0	0	0	1-2x/b+x ² /b ²	0+0	1/3Xb/EJ
AI b	-x/b	0	0	0	0	x ² /b ²		
	totali						-5/2Fb ² /EJ	5/3Xb/EJ
	iperstatica X=W _{IE}						3/2Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

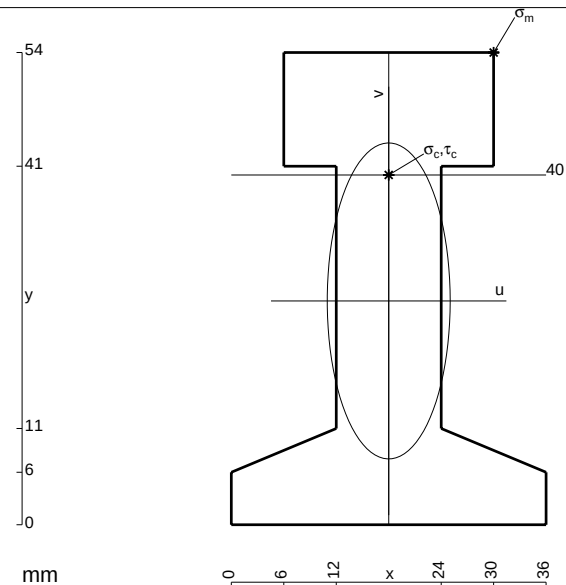
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

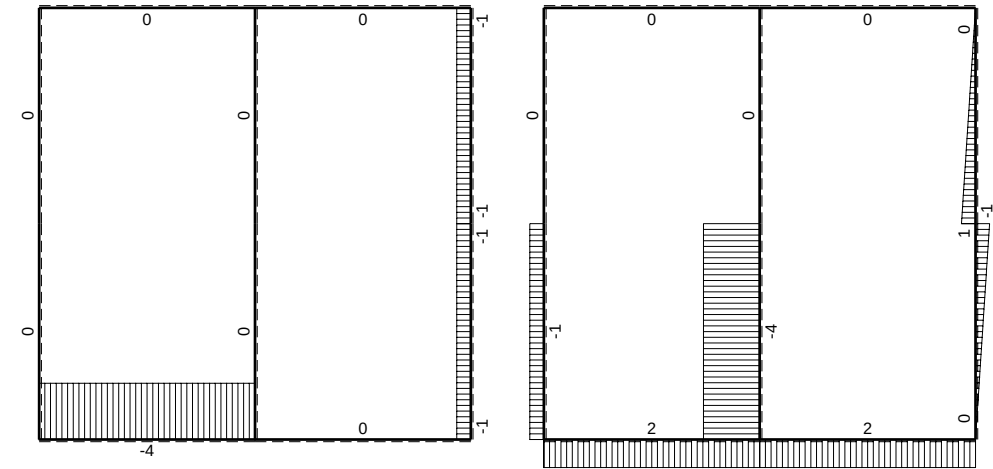
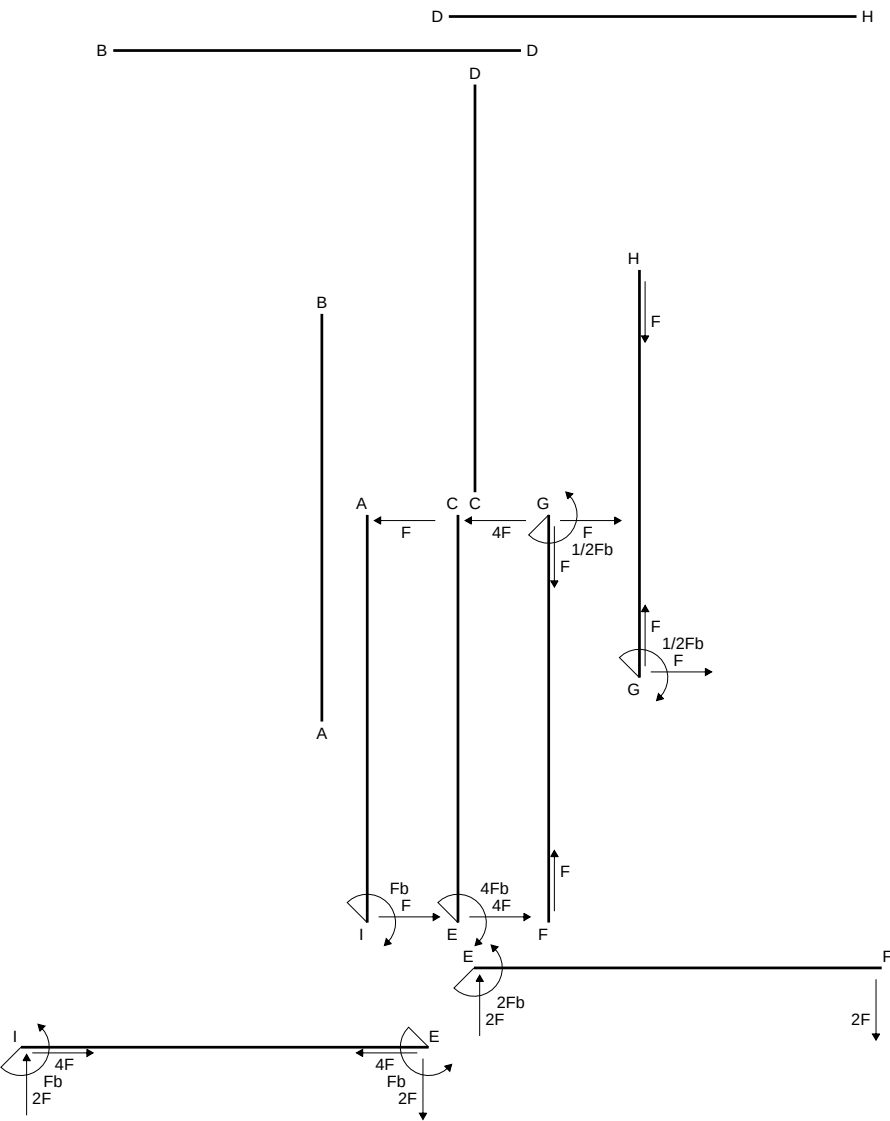
$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

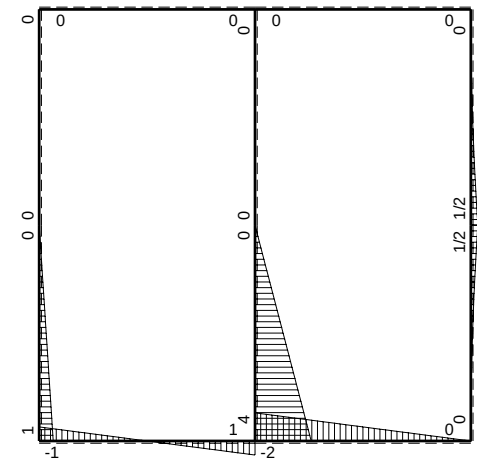


$$\begin{aligned} A &= 1008. \text{ mm}^2 \\ J_u &= 329111. \text{ mm}^4 \\ J_v &= 49824. \text{ mm}^4 \\ y_g &= 25.59 \text{ mm} \\ T_y &= 2800. \text{ N} \\ M_x &= -2548000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.41 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219.9 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 14.41 \text{ mm} \\ \sigma_c &= -Mv/J_u = 111.5 \text{ N/mm}^2 \\ \tau_c &= 4.973 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 111.9 \text{ N/mm}^2 \\ S &= 7014. \text{ mm}^3 \end{aligned}$$

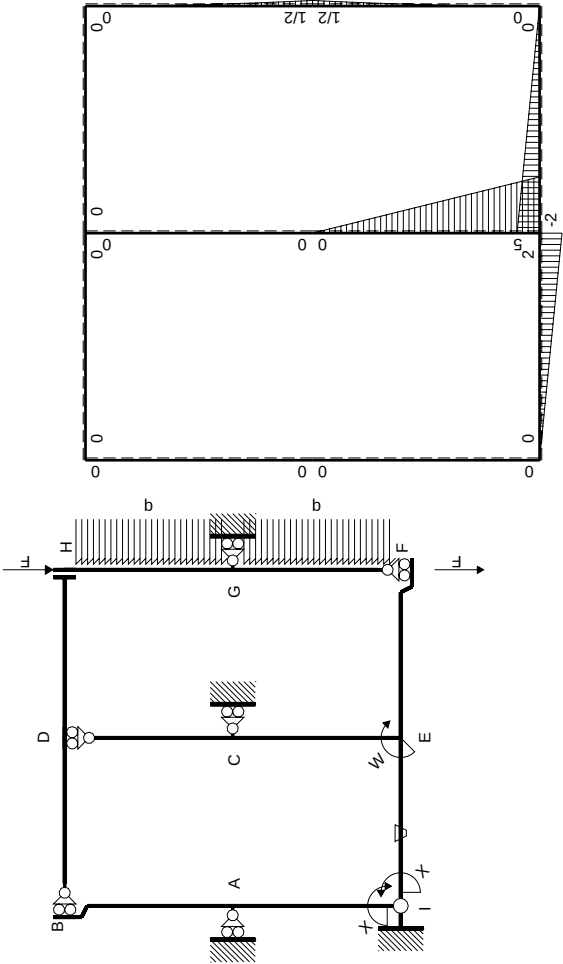


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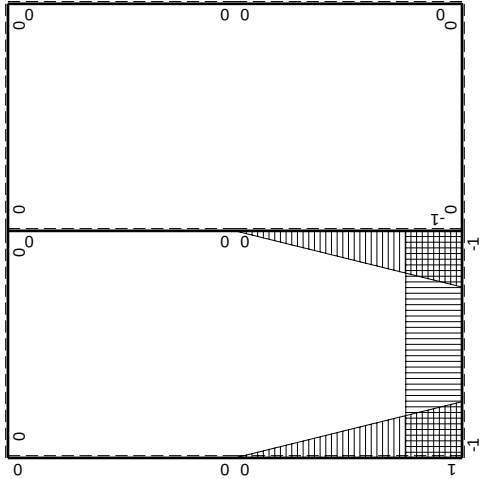


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

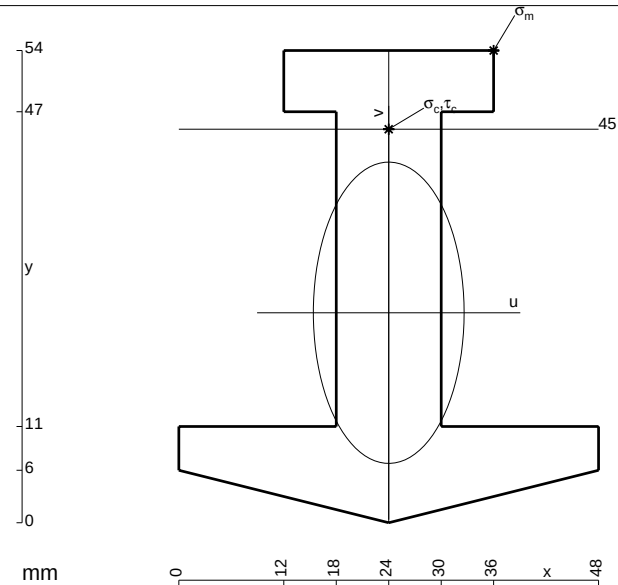
$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

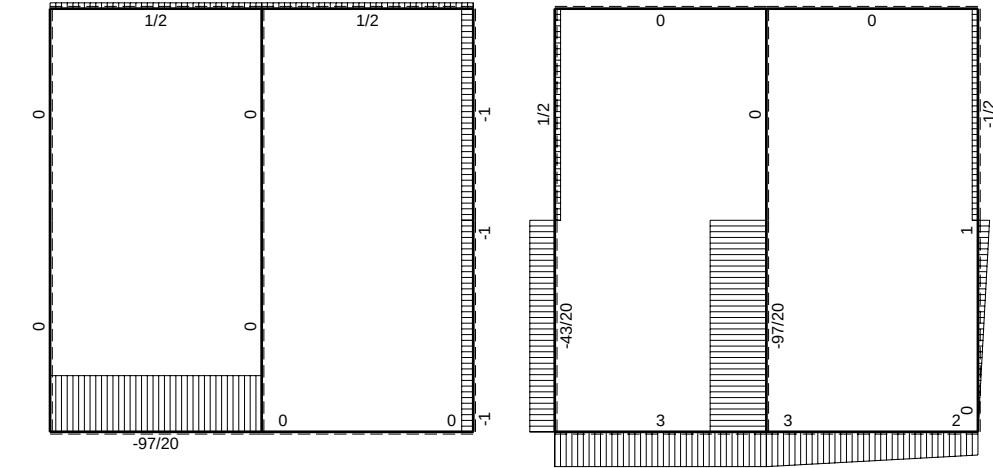
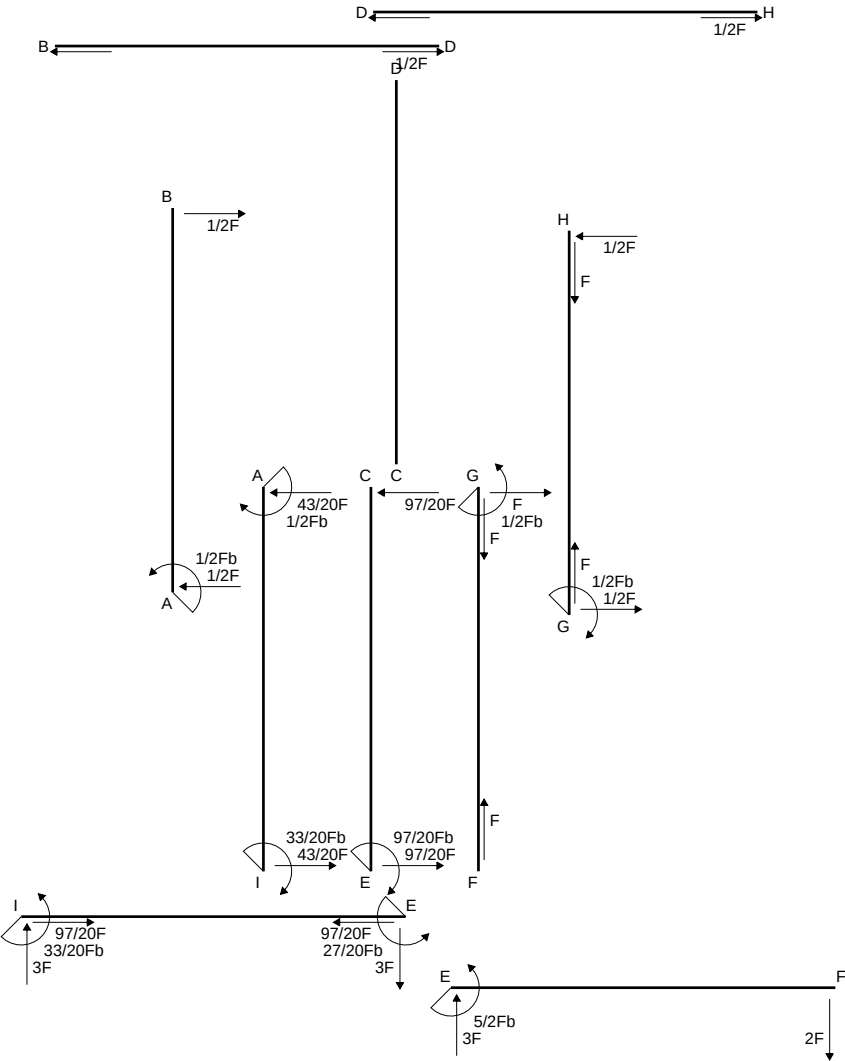
$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

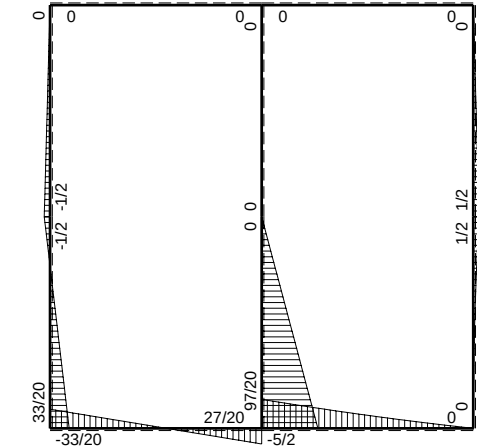


$$\begin{aligned} A &= 984. \text{ mm}^2 \\ J_u &= 292168. \text{ mm}^4 \\ J_v &= 73152. \text{ mm}^4 \\ y_g &= 24.01 \text{ mm} \\ T_y &= 2300. \text{ N} \\ M_x &= -2231000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.99 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 20.99 \text{ mm} \\ \sigma_c &= -Mv/J_u = 160.3 \text{ N/mm}^2 \\ \tau_c &= 3.265 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 160.4 \text{ N/mm}^2 \\ S &= 4978. \text{ mm}^3 \end{aligned}$$

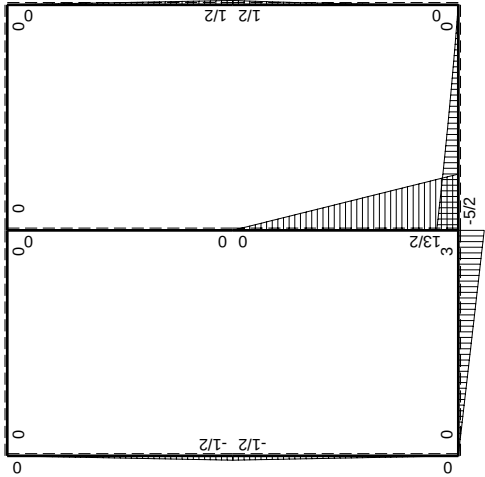
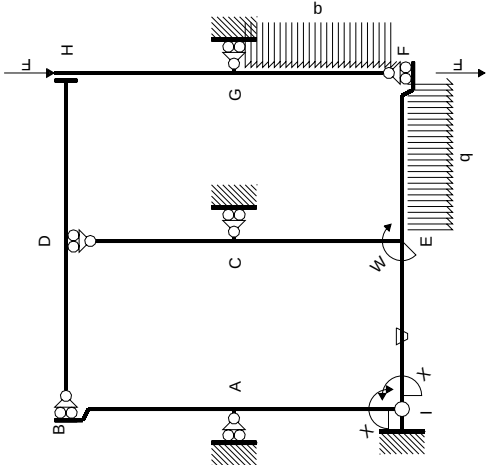


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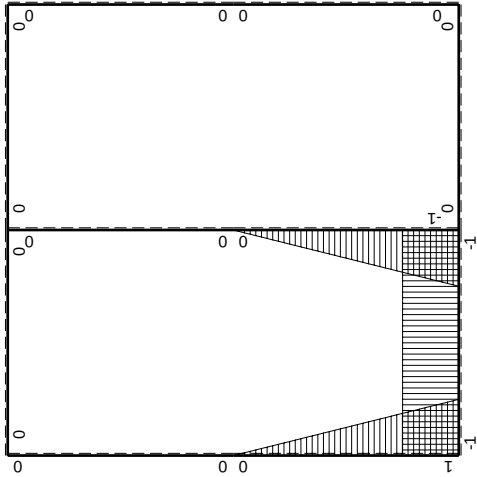


⊕ ⊖ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

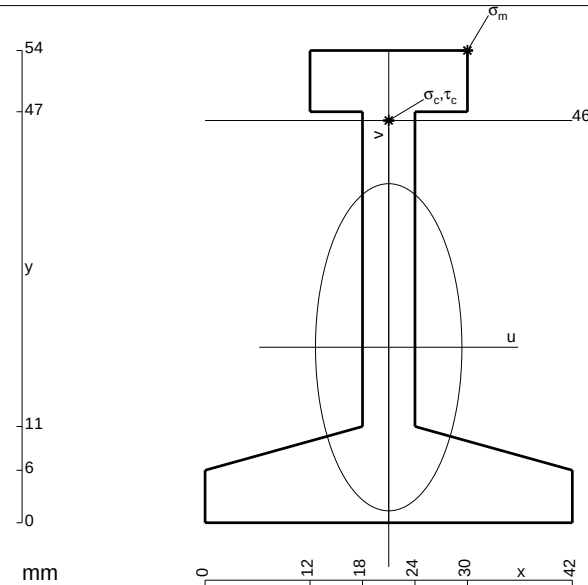
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 714. \text{ mm}^2$$

$$J_u = 249976. \text{ mm}^4$$

$$J_v = 50094. \text{ mm}^4$$

$$y_g = 20.07 \text{ mm}$$

$$T_y = 2070. \text{ N}$$

$$M_x = -1759500. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 33.93 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.8 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

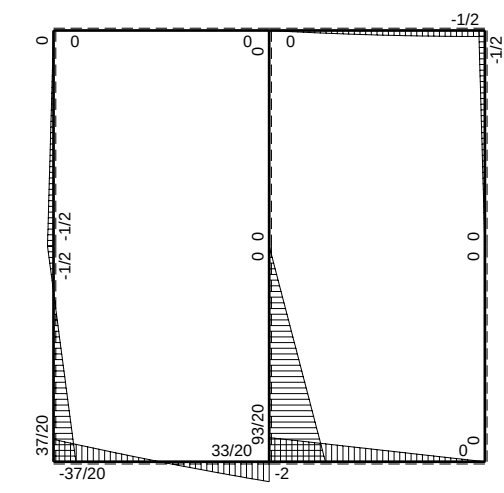
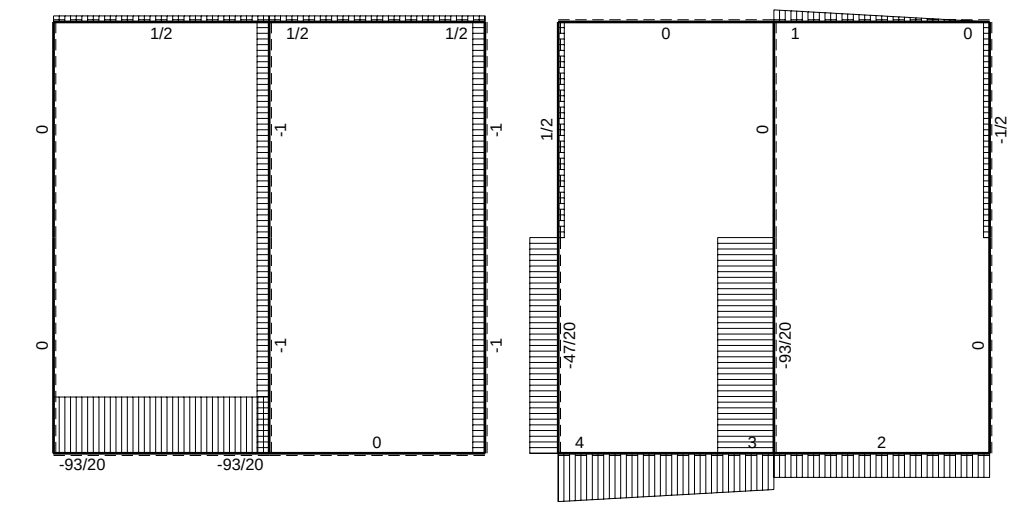
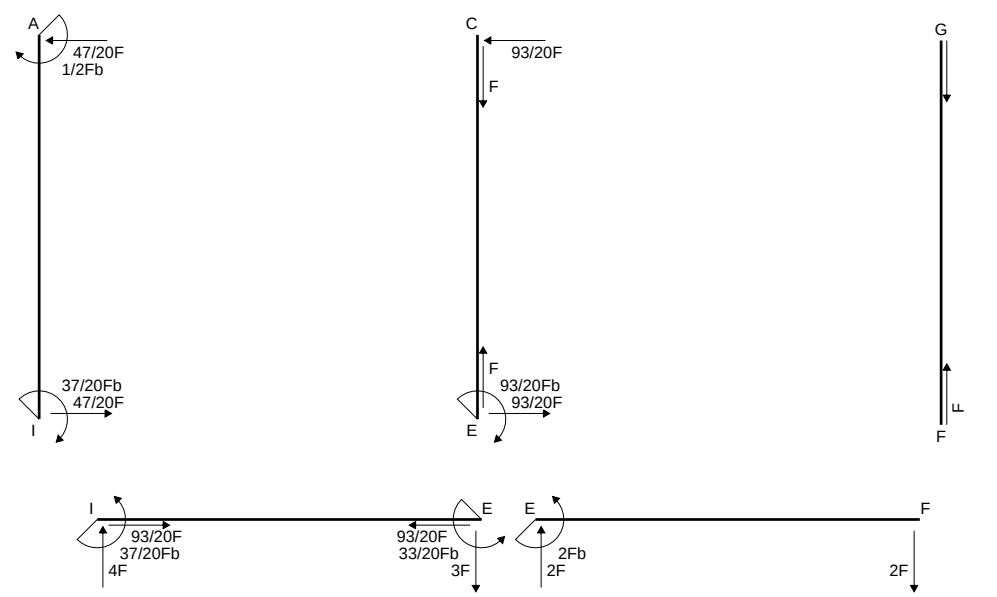
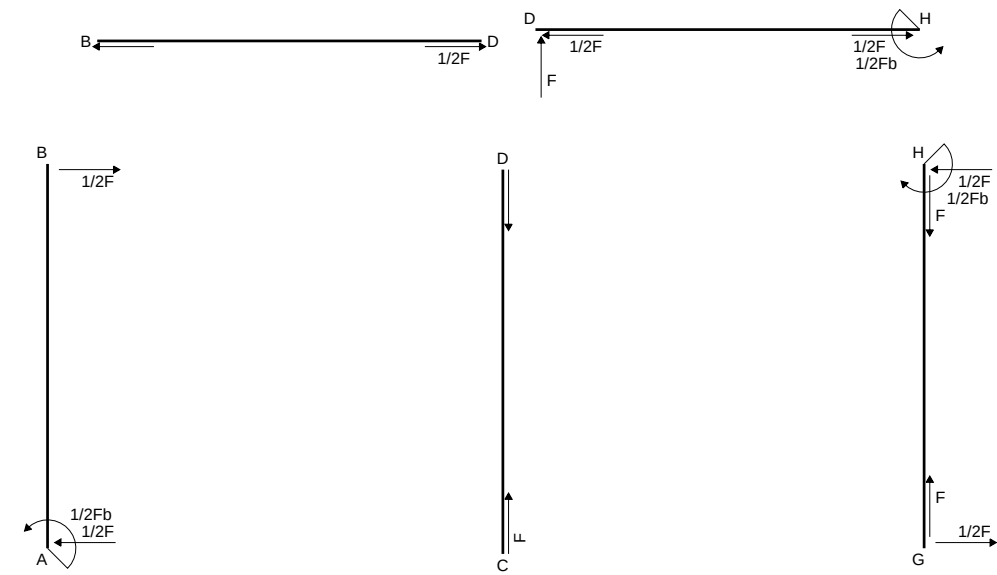
$$v_c = 25.93 \text{ mm}$$

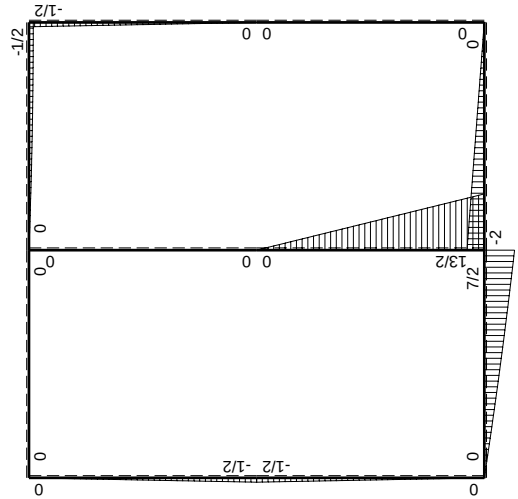
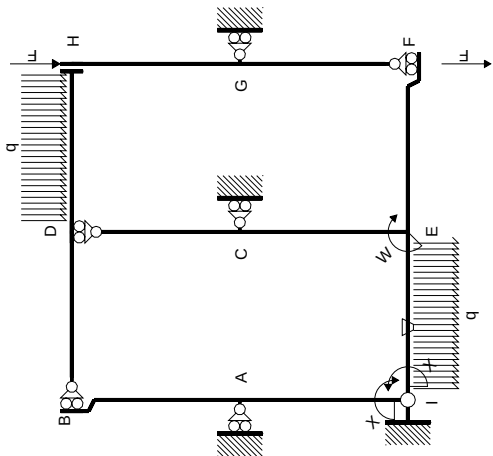
$$\sigma_c = -Mv/J_u = 182.5 \text{ N/mm}^2$$

$$\tau_c = 5.511 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 182.8 \text{ N/mm}^2$$

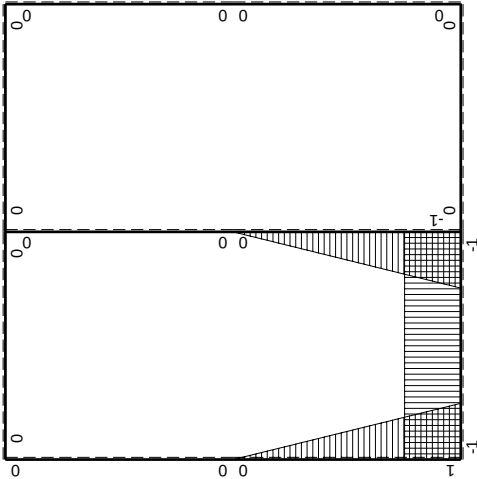
$$S = 3993. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-37/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$37/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

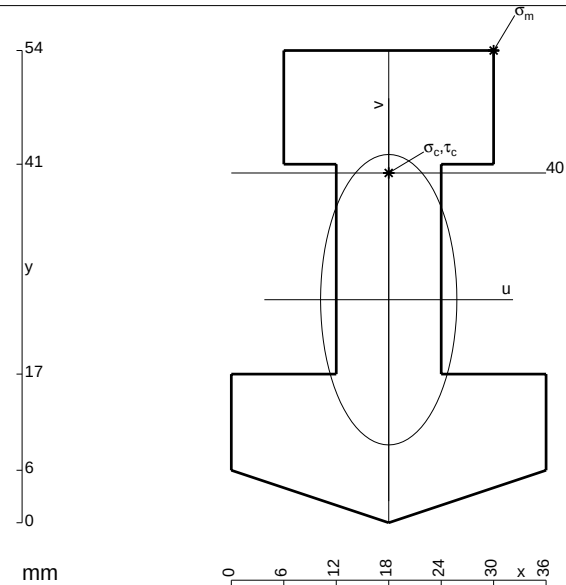
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

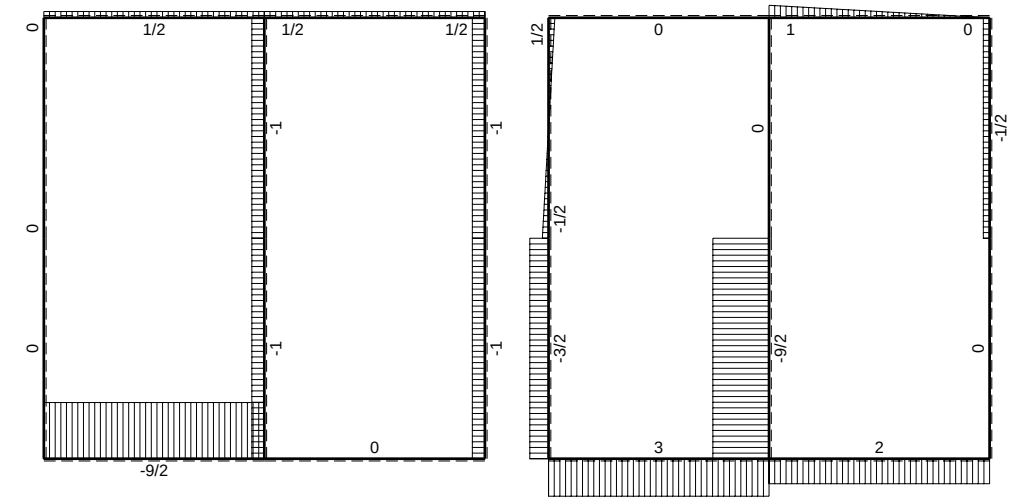
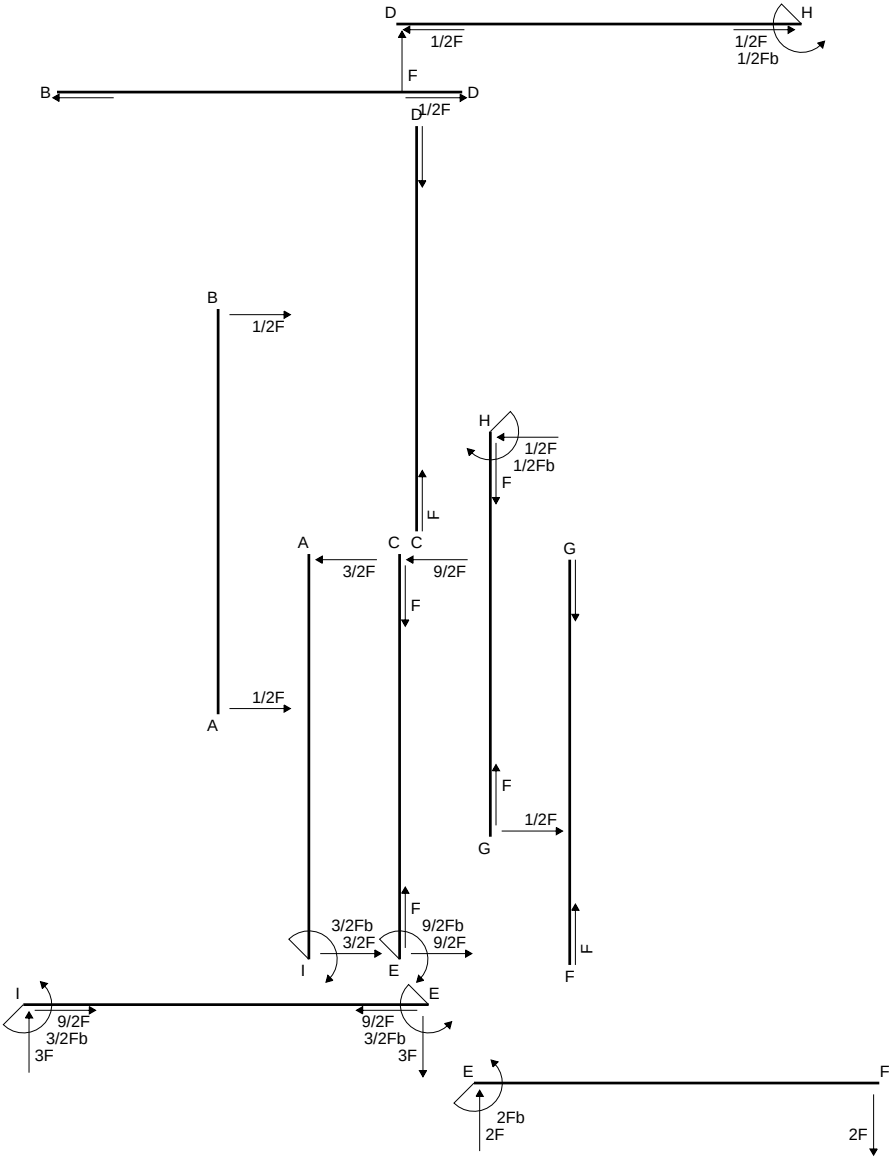
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

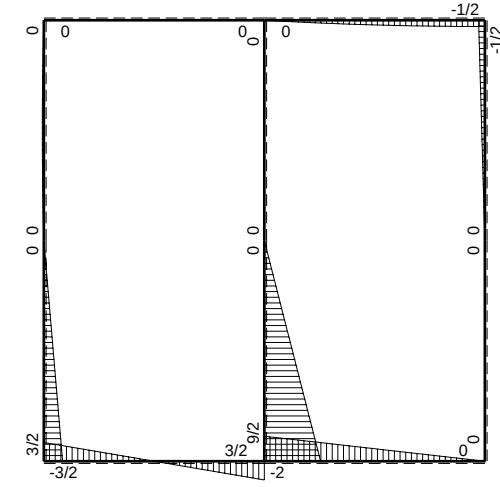


$$\begin{aligned} A &= 1104. \text{ mm}^2 \\ J_u &= 304502. \text{ mm}^4 \\ J_v &= 67032. \text{ mm}^4 \\ y_g &= 25.51 \text{ mm} \\ T_y &= 3940. \text{ N} \\ M_x &= -2127600. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.49 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.1 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 14.49 \text{ mm} \\ \sigma_c &= -Mv/J_u = 101.3 \text{ N/mm}^2 \\ \tau_c &= 7.593 \text{ N/mm}^2 \\ \sigma_o^* &= \sqrt{\sigma^2 + 3\tau^2} = 102.1 \text{ N/mm}^2 \\ S &= 7042. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

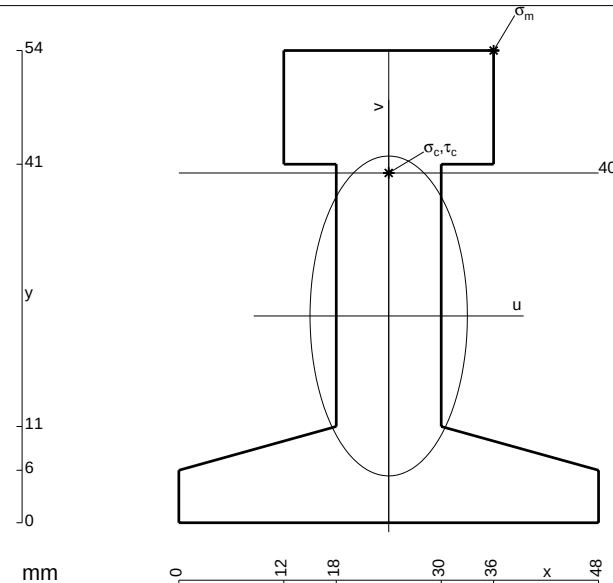
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

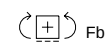
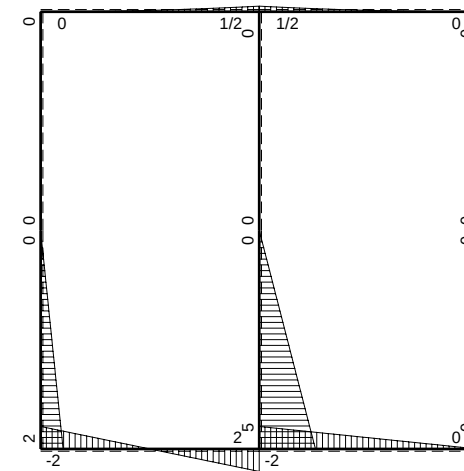
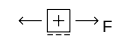
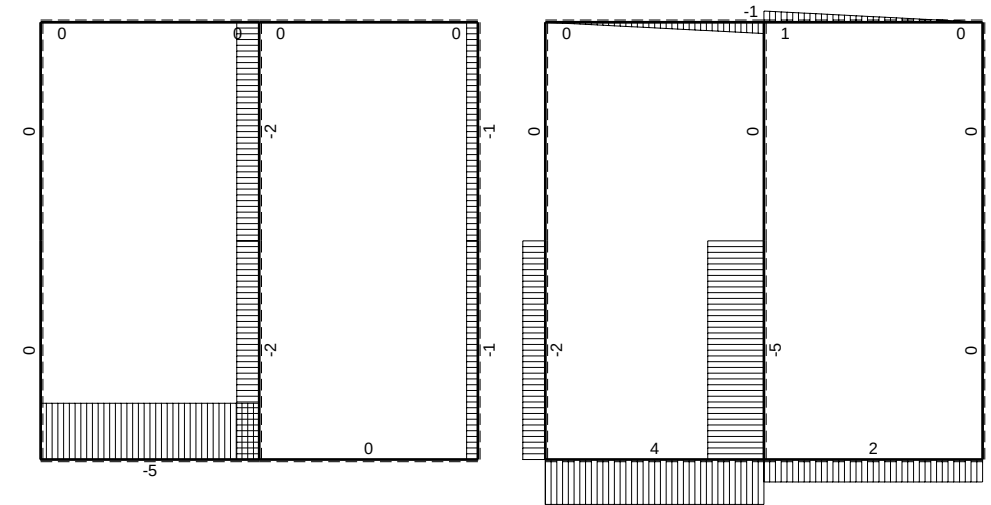
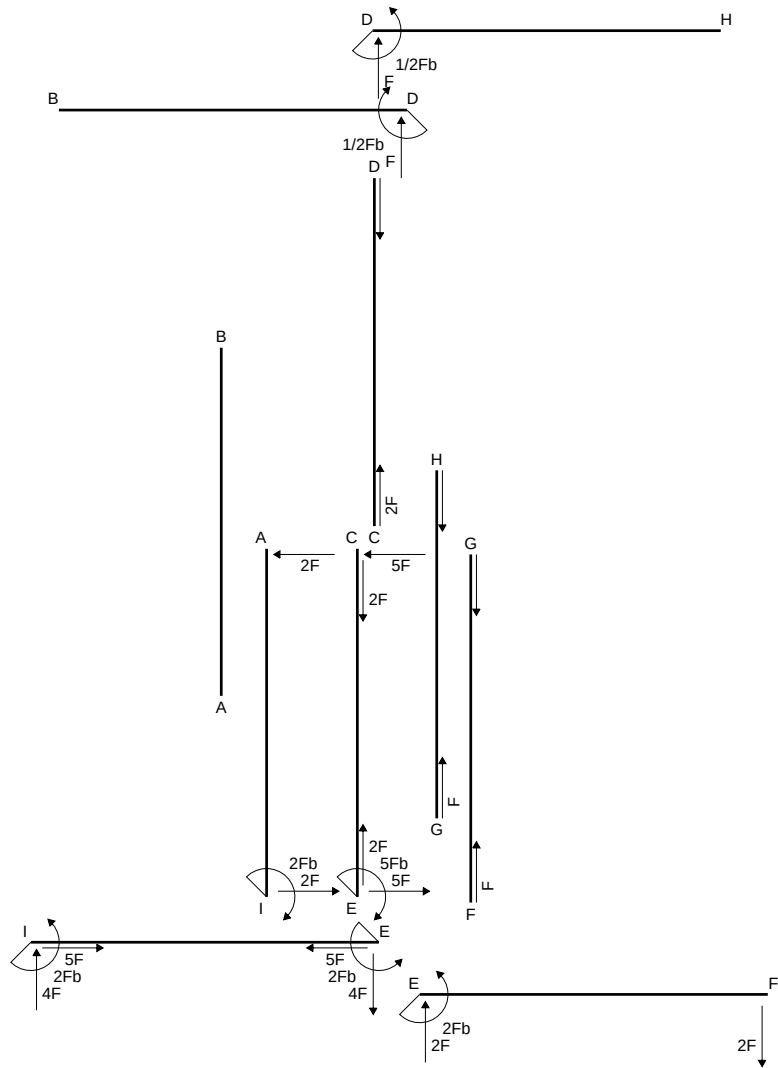
$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

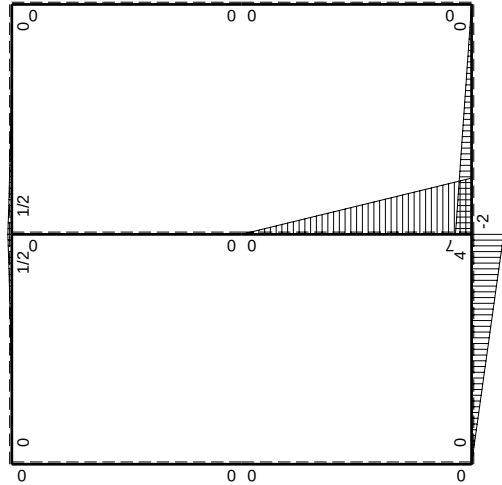
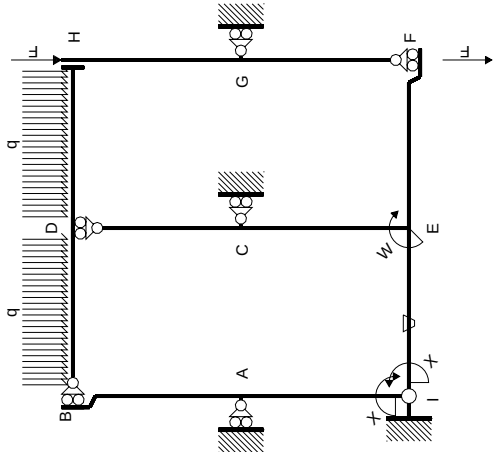
$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$



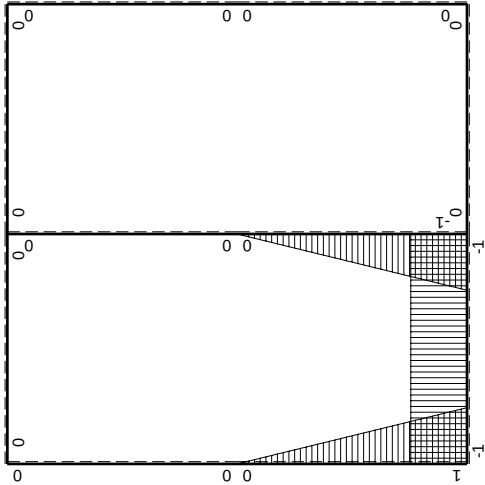
$$\begin{aligned} A &= 1110. \text{ mm}^2 \\ J_u &= 371542. \text{ mm}^4 \\ J_v &= 89892. \text{ mm}^4 \\ y_g &= 23.64 \text{ mm} \\ T_y &= 4340. \text{ N} \\ M_x &= -2560600. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.36 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.2 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 16.36 \text{ mm} \\ \sigma_c &= -Mv/J_u = 112.7 \text{ N/mm}^2 \\ \tau_c &= 7.442 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 113.5 \text{ N/mm}^2 \\ S &= 7646. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$7Fb-7Fx$	0	$-7Fb+14Fx-7Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-7Fx$	0	$-7Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-10/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						2Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

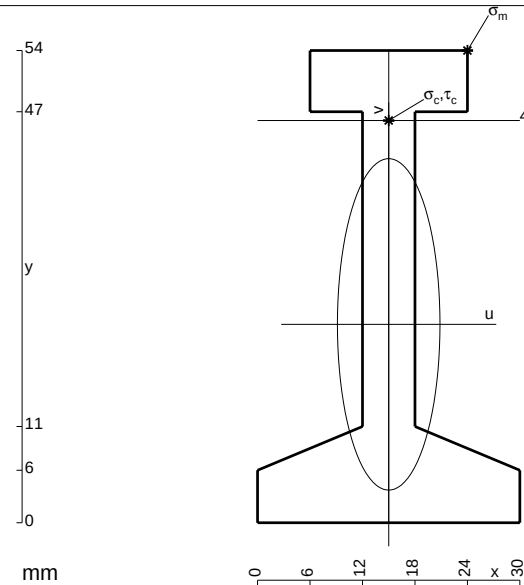
$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-7 + 14x/b - 7x^2/b^2) Fb \frac{1}{EJ} dx = \left[-7x + 7x^2/b - 7/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

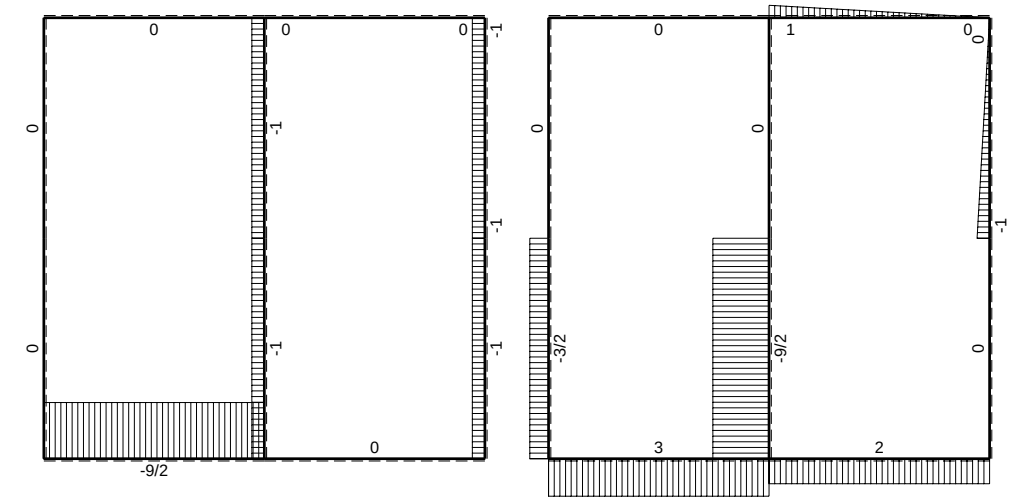
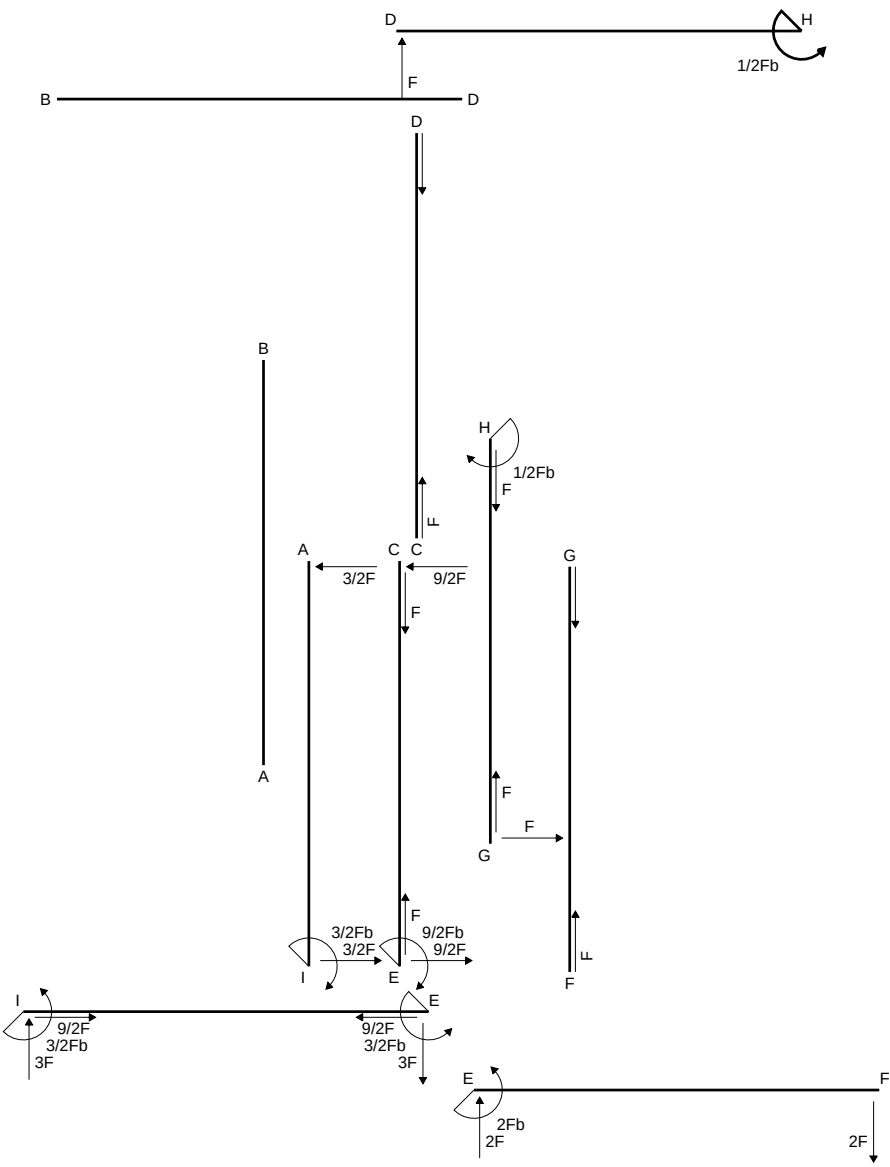
$$= (-7b + 7b - 7/3 b) Fb \frac{1}{EJ} = -7/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-7x^2/b^2) Fb \frac{1}{EJ} dx = \left[-7/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-7/3 b) Fb \frac{1}{EJ} = -7/3 Fb^2/EJ$$

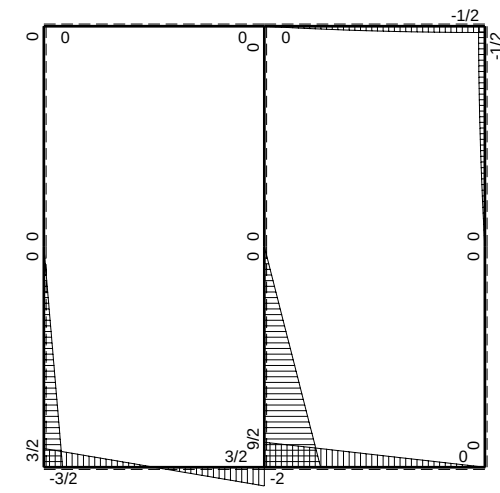


$$\begin{aligned} A &= 612. \text{ mm}^2 \\ J_u &= 219945. \text{ mm}^4 \\ J_v &= 21060. \text{ mm}^4 \\ y_g &= 22.68 \text{ mm} \\ T_y &= 2400. \text{ N} \\ M_x &= -1536000. \text{ Nmm} \\ x_m &= 24. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 31.32 \text{ mm} \\ \sigma_m &= -Mv/J_u = 218.7 \text{ N/mm}^2 \\ x_c &= 15. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 23.32 \text{ mm} \\ \sigma_c &= -Mv/J_u = 162.8 \text{ N/mm}^2 \\ \tau_c &= 6.634 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 163.2 \text{ N/mm}^2 \\ S &= 3648. \text{ mm}^3 \end{aligned}$$

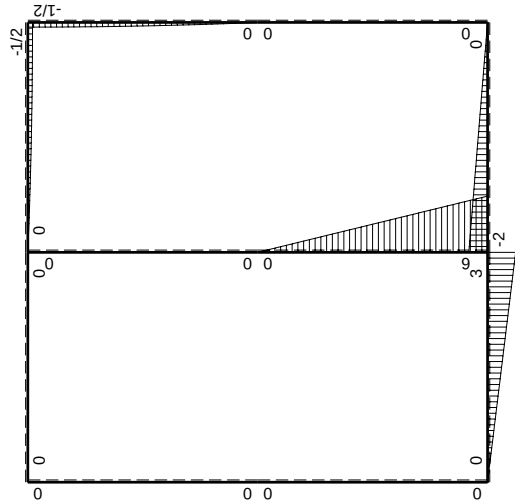
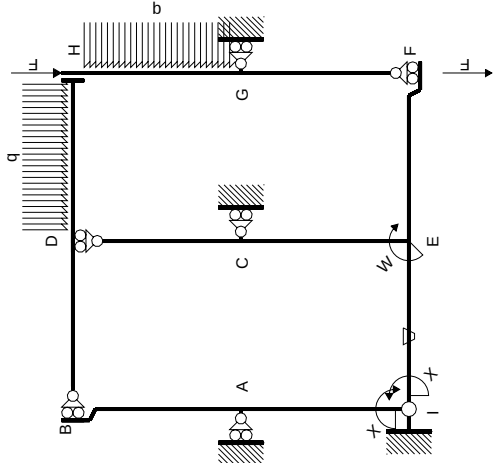


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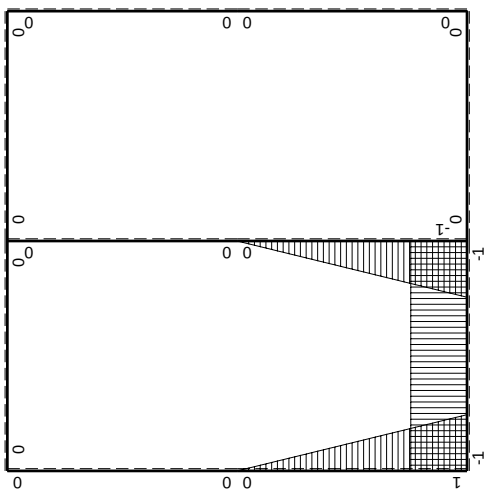


⊕ ⊖ Fb



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-Fx+1/2qx ²	0	0	0	0	0+0	0
HG b	0	1/2Fb-1/2qx ²	0	0	0	0		
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0
DH b	0	Fx-1/2qx ²	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	-1+x/b	6Fb-6Fx	0	-6Fb+12Fx-6Fx ² /b	0	1-2x/b+x ² /b ²	(-2+0)Fb ² /EJ	1/3Xb/EJ
CE b	x/b	-6Fx	0	-6Fx ² /b	0	x ² /b ²		
IA b	1-x/b	0	0	0	0	1-2x/b+x ² /b ²	0+0	1/3Xb/EJ
AI b	-x/b	0	0	0	0	x ² /b ²		
	totali						-5/2Fb ² /EJ	5/3Xb/EJ
	iperstatica $X=W_{IE}$						3/2Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

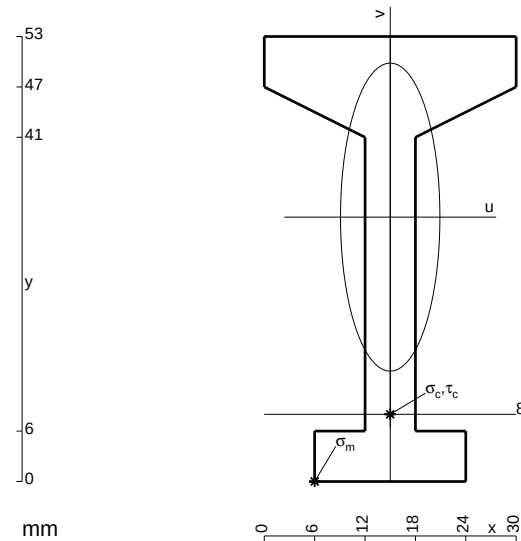
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$



$$A = 606. \text{ mm}^2$$

$$J_u = 204068. \text{ mm}^4$$

$$J_v = 21258. \text{ mm}^4$$

$$y_g = 31.49 \text{ mm}$$

$$T_y = 2180. \text{ N}$$

$$M_x = -1482400. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -31.49 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -228.8 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 8. \text{ mm}$$

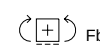
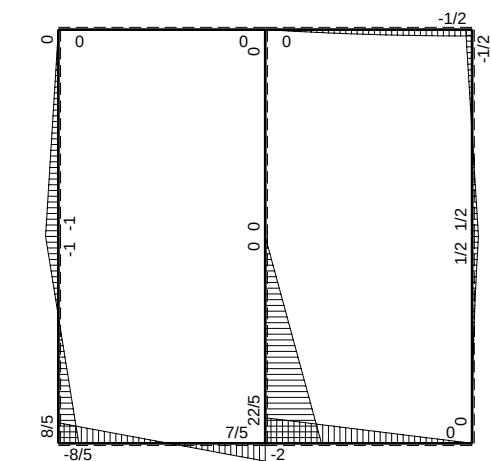
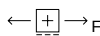
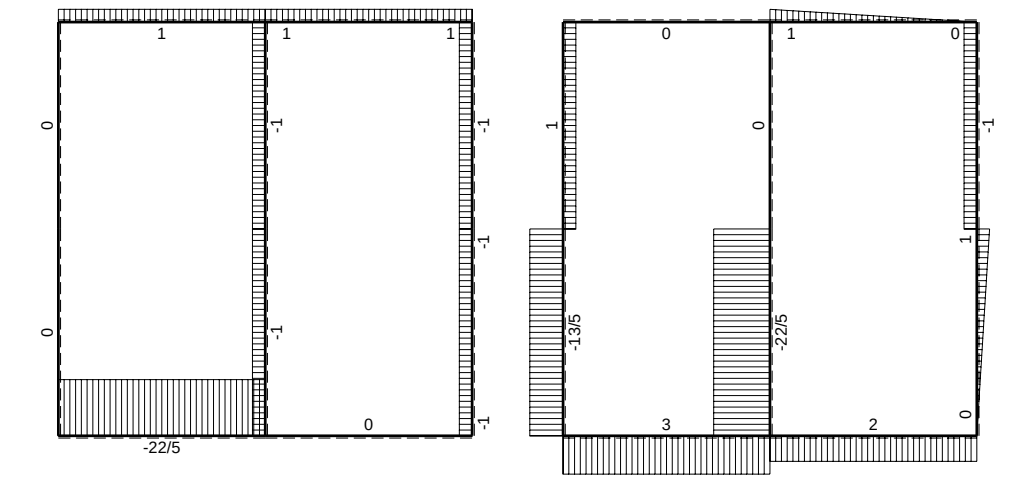
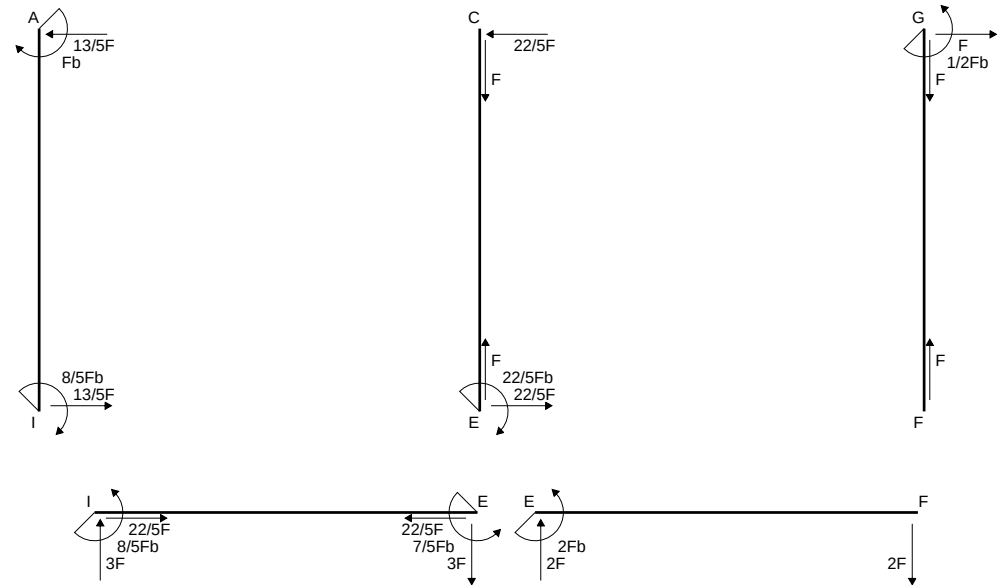
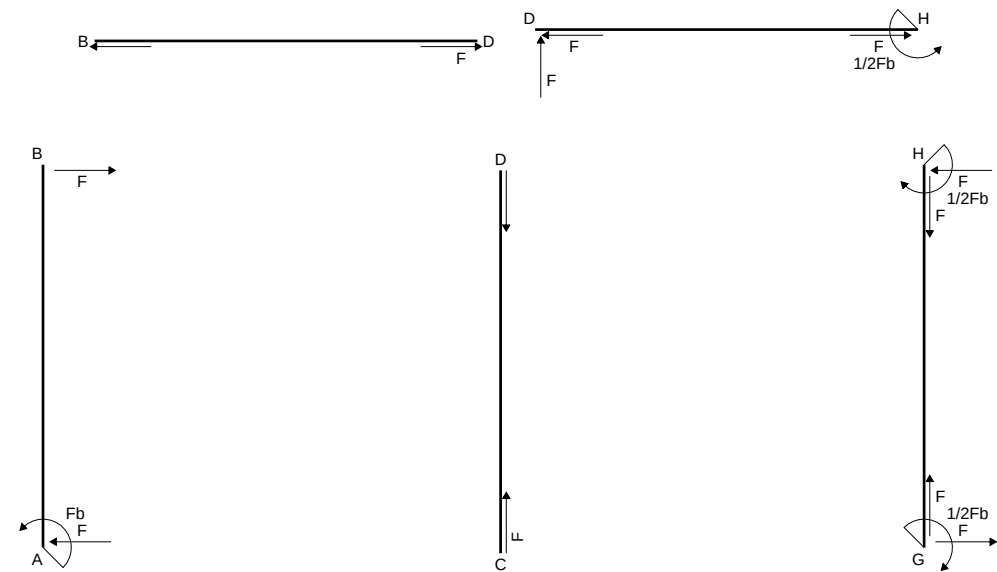
$$v_c = -23.49 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -170.6 \text{ N/mm}^2$$

$$\tau_c = 6.002 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 171. \text{ N/mm}^2$$

$$S^* = 3371. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

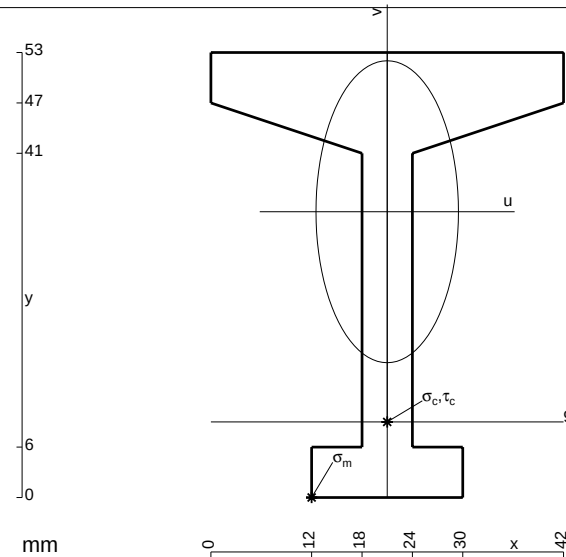
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 714. \text{ mm}^2$$

$$J_u = 230961. \text{ mm}^4$$

$$J_v = 51390. \text{ mm}^4$$

$$y_g = 34.04 \text{ mm}$$

$$T_y = 2200. \text{ N}$$

$$M_x = -1628000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.04 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.9 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

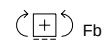
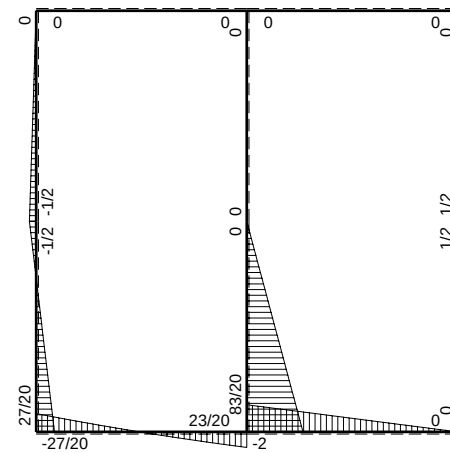
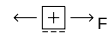
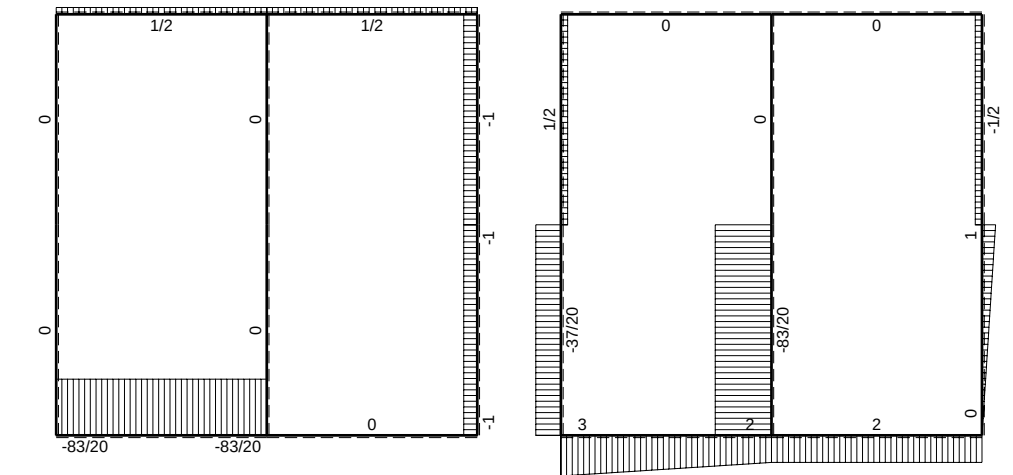
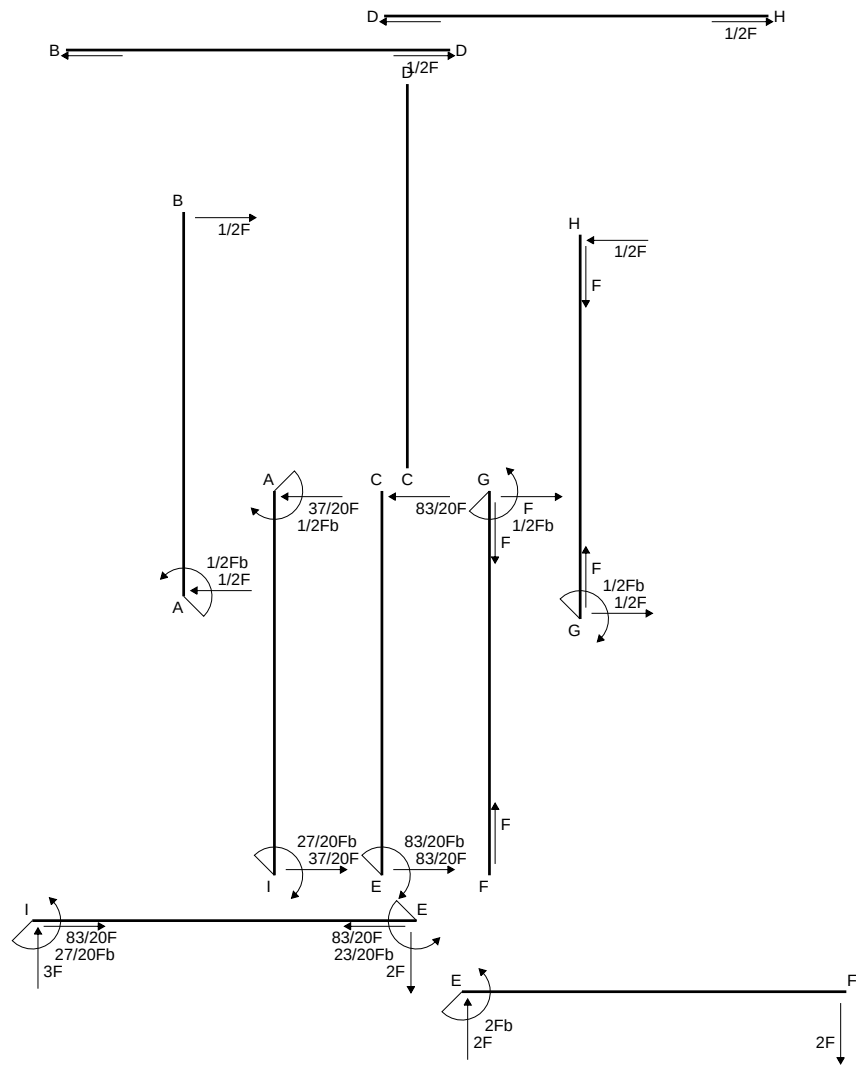
$$v_c = -25.04 \text{ mm}$$

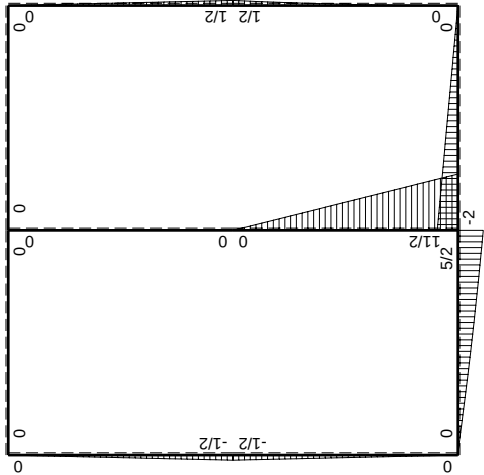
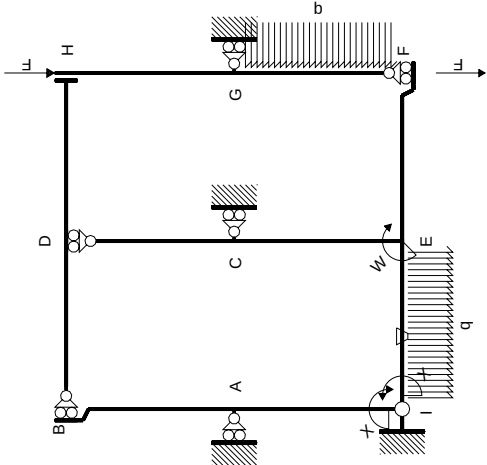
$$\sigma_c = -Mv/J_u = -176.5 \text{ N/mm}^2$$

$$\tau_c = 6.08 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 176.8 \text{ N/mm}^2$$

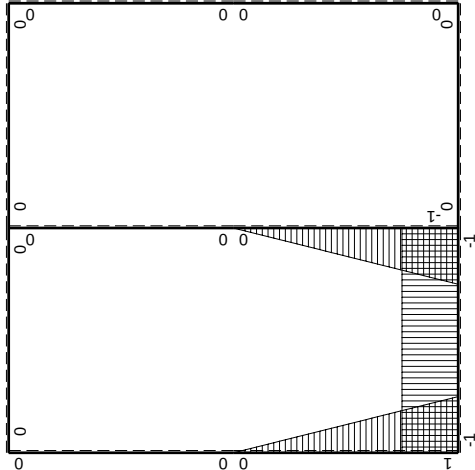
$$S = 3830. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-9/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$27/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

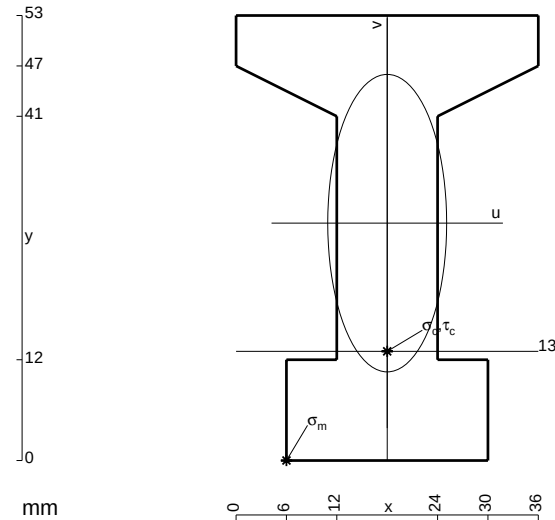
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 996. \text{ mm}^2$$

$$J_u = 312739. \text{ mm}^4$$

$$J_v = 49968. \text{ mm}^4$$

$$y_g = 28.27 \text{ mm}$$

$$T_y = 2800. \text{ N}$$

$$M_x = -2212000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.27 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -200. \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

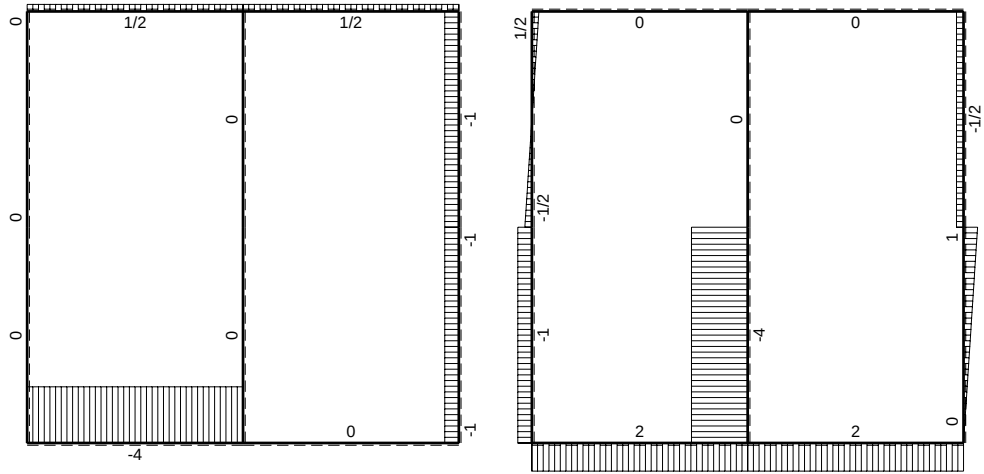
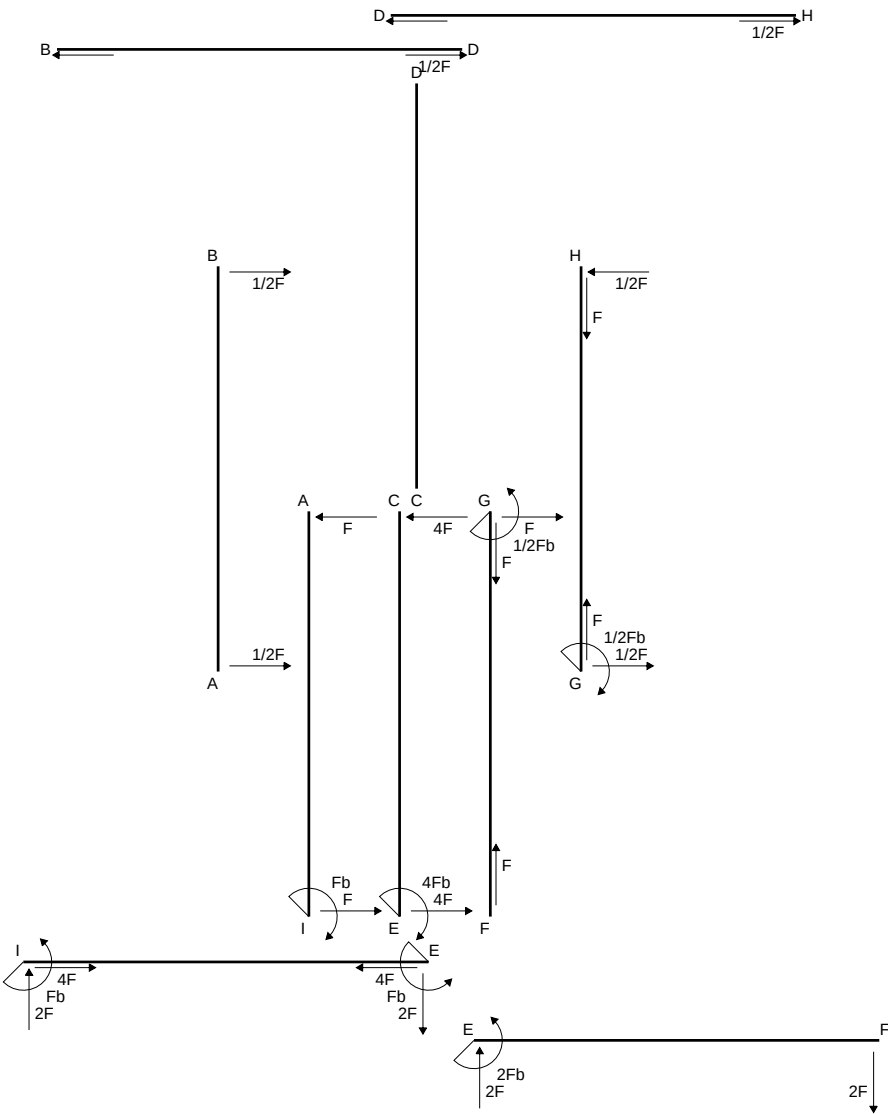
$$v_c = -15.27 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -108. \text{ N/mm}^2$$

$$\tau_c = 4.927 \text{ N/mm}^2$$

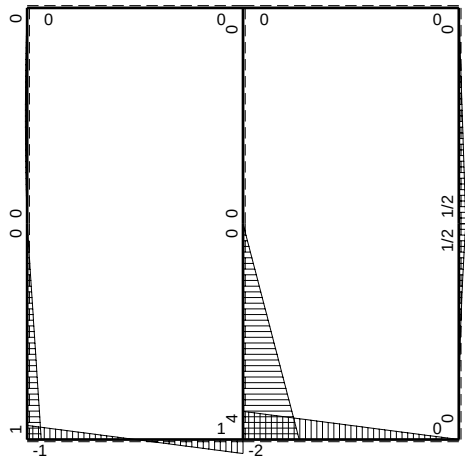
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 108.3 \text{ N/mm}^2$$

$$S = 6603. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{XX} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \cdot 1/EJ \, dx = \left[x \right]_0^b \cdot 1/EJ$$

$$= (b) \frac{1}{EJ} = \frac{b}{EJ}$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + \frac{1}{3}b) \frac{1}{EJ} = \frac{1}{3} \frac{b}{EJ}$$

$$L_{CE}^{xx} = \int_0^b \left(x^2/b^2 \right) 1/EJ \, dx = \left[1/3 x^3/b^2 \right]_0^b 1/EJ$$

$$= \left(\frac{1}{3} b \right) \frac{1}{EJ} = \frac{1}{3} \frac{b}{EJ}$$

$$L_{IA}^{XX} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + \frac{1}{3} x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + \frac{1}{3}b) \frac{1}{EJ} = \frac{1}{3} \frac{b}{EJ}$$

$$L_{AI}^{XX} = \int_0^b (x^2/b^2) \cdot 1/EJ \, dx = \left[1/3 x^3/b^2 \right]_0^b \cdot 1/EJ$$

$$= (1/3 b) 1/EJ = 1/3 b/EJ$$

$$L_{IE}^{X_0} = \int_0^b (-2x/b) Fb/EJ \, dx + \int_0^b (1) \theta \, dx = \left[-x^2/b \right]_0^b Fb/EJ + \left[x \right]_0^b \theta$$

$$= (-b) Fb 1/EJ + (b) \theta = 0$$

$$L_{EI}^{XO} = \int_0^b (-2 + 2x/b) Fb \, 1/EJ \, dx + \int_0^b (-1) \theta \, dx = \left[-2x + x^2/b \right]_0^b Fb \, 1/EJ + \left[-x \right]_0^b \theta$$

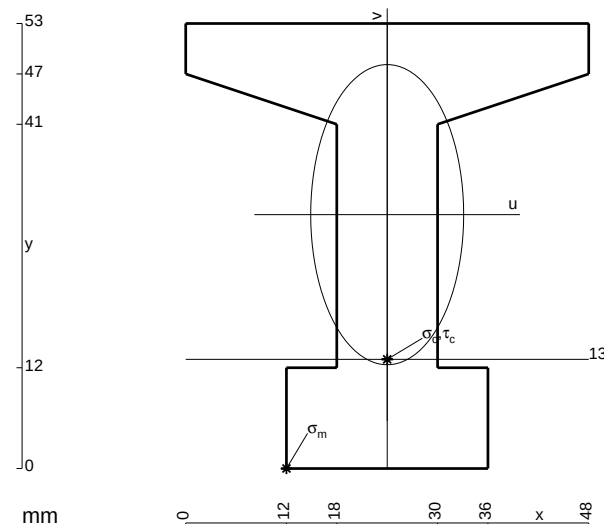
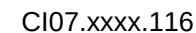
$$= (-2b + b) Fb 1/EJ + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 10 x/b - 5 x^2/b^2) Fb \, 1/EJ \, dx = \left[-5 x + 5 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \, 1/EJ$$

$$= (-5b + 5b - 5/3b) Fb 1/EJ = -5/3 Fb^2/EJ$$

$$L_{CE}^{X_0} = \int_0^b (-5 x^2/b^2) Fb \, 1/EJ \, dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \, 1/EJ$$

$$= \left(-\frac{5}{3} b \right) Fb \frac{1}{EJ} = -\frac{5}{3} \frac{Fb^2}{EJ}$$



$$A = 1104. \text{ mm}^2$$

$$J_u = 352844. \text{ mm}^4$$

$$J_v = 91656. \text{ mm}^4$$

$$y_g = 30.23 \text{ mm}$$

$$T_y = 2900. \text{ N}$$

$$M_x = -2436000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.23 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.7 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

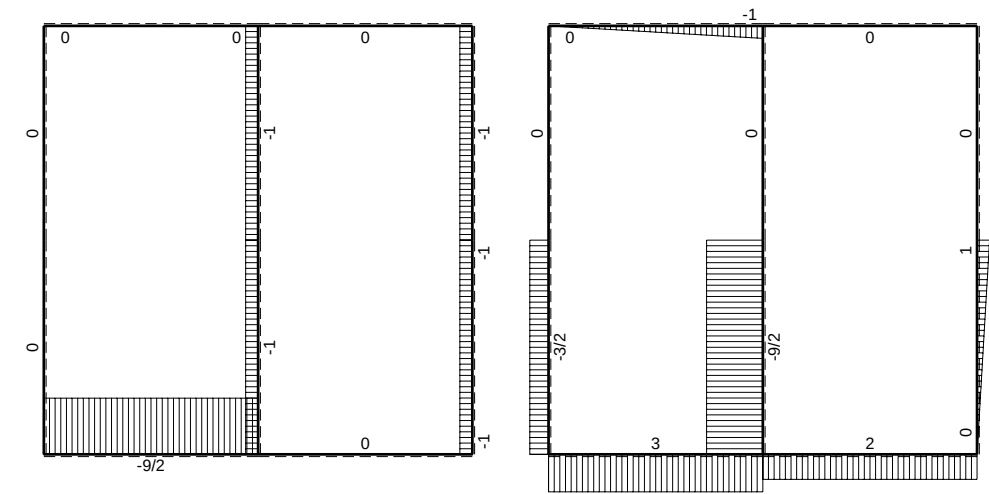
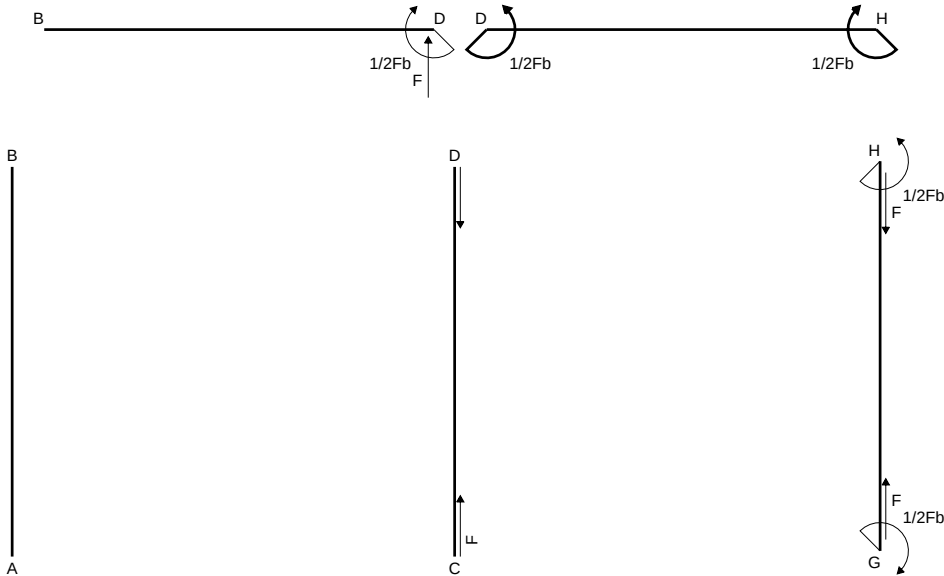
$$v_c = -17.23 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -119. \text{ N/mm}^2$$

$$\tau_c = 4.926 \text{ N/mm}^2$$

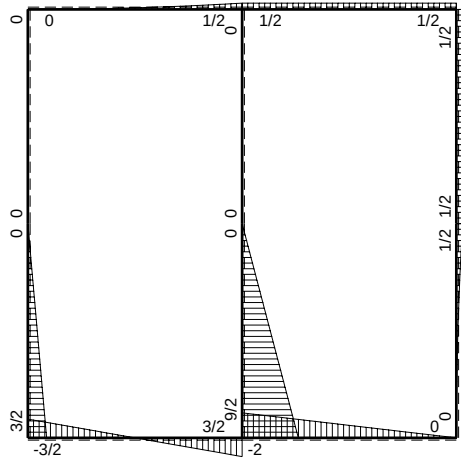
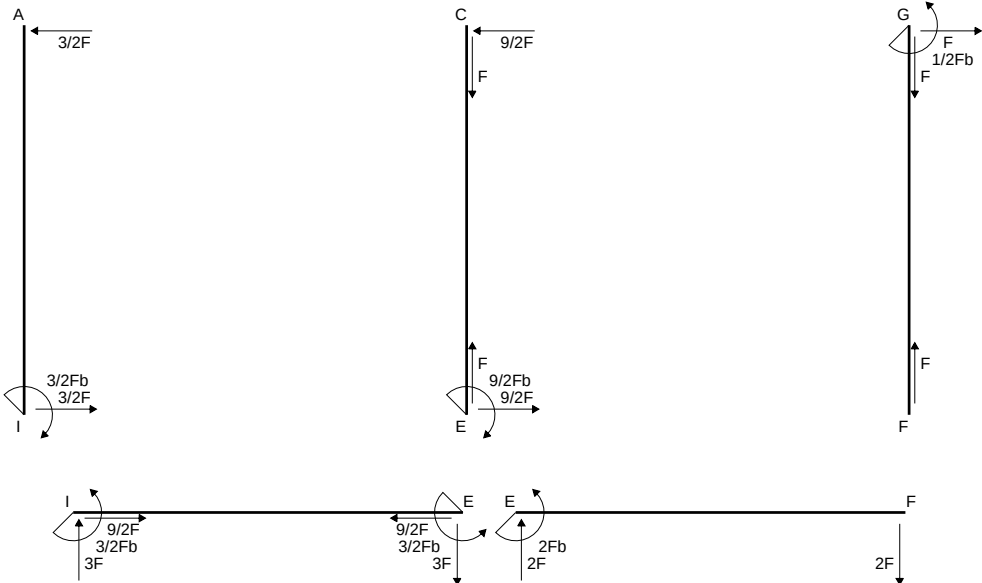
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 119.3 \text{ N/mm}^2$$

$$S^* = 7192. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

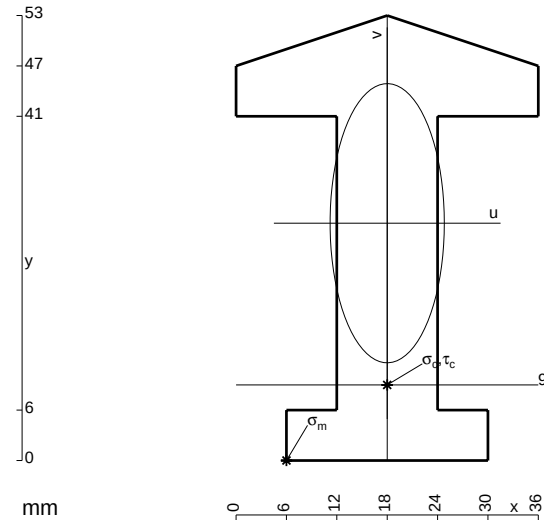
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x0} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{x0} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$



$$A = 888. \text{ mm}^2$$

$$J_u = 245538. \text{ mm}^4$$

$$J_v = 41112. \text{ mm}^4$$

$$y_g = 28.26 \text{ mm}$$

$$T_y = 2120. \text{ N}$$

$$M_x = -1908000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.26 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

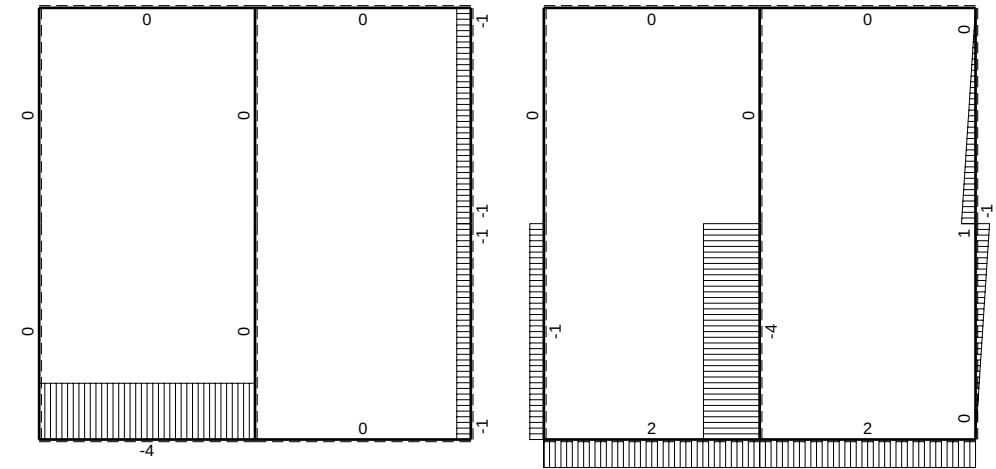
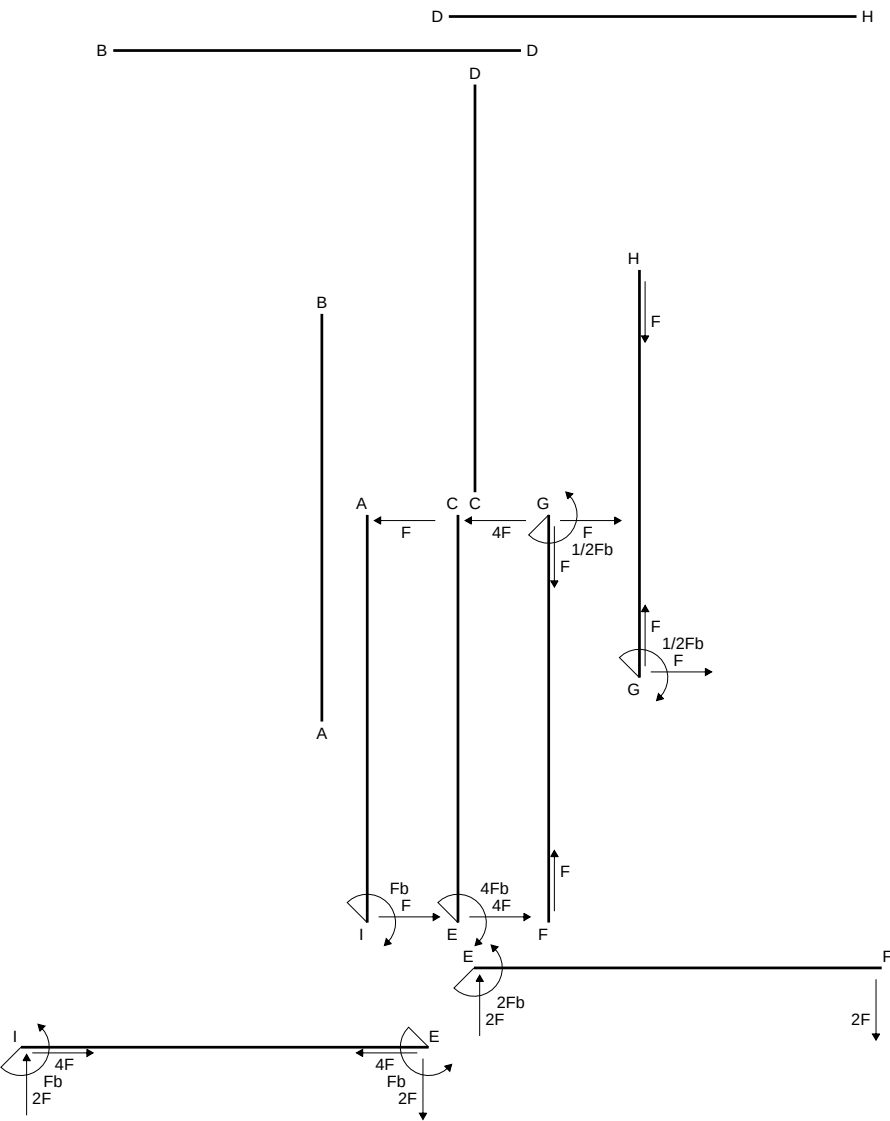
$$v_c = -19.26 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -149.7 \text{ N/mm}^2$$

$$\tau_c = 3.155 \text{ N/mm}^2$$

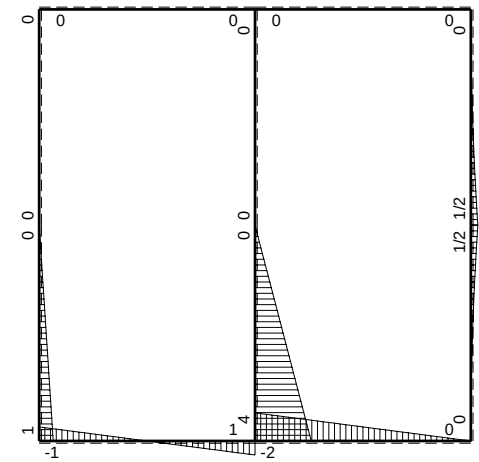
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 149.8 \text{ N/mm}^2$$

$$S = 4385. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

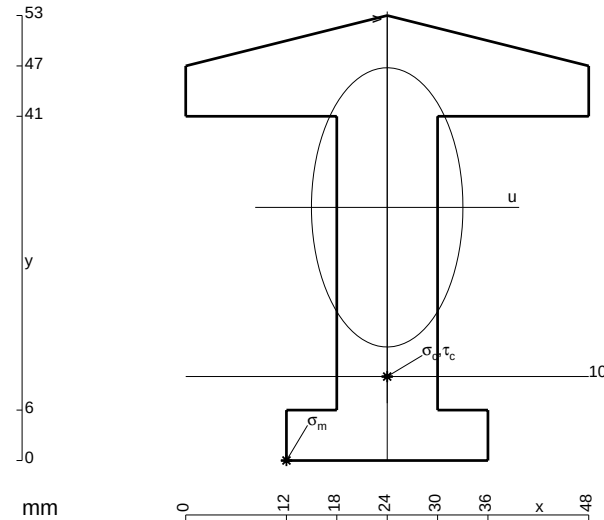
$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

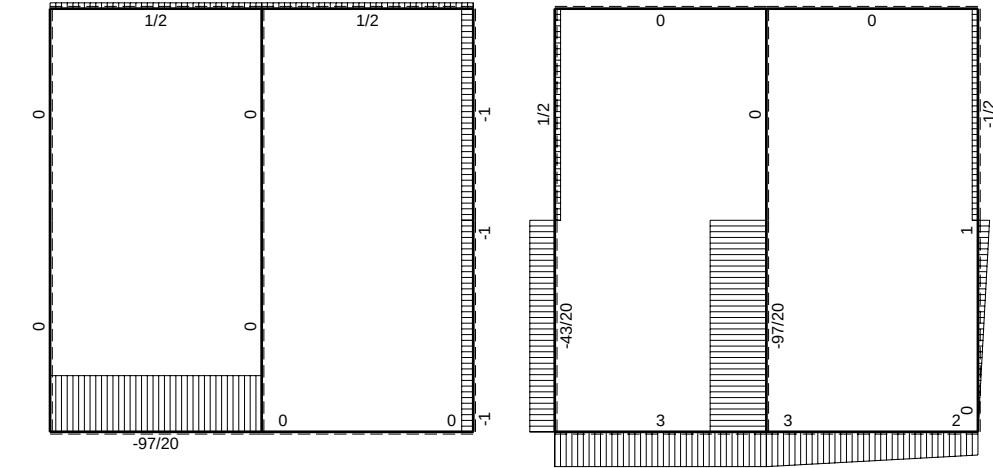
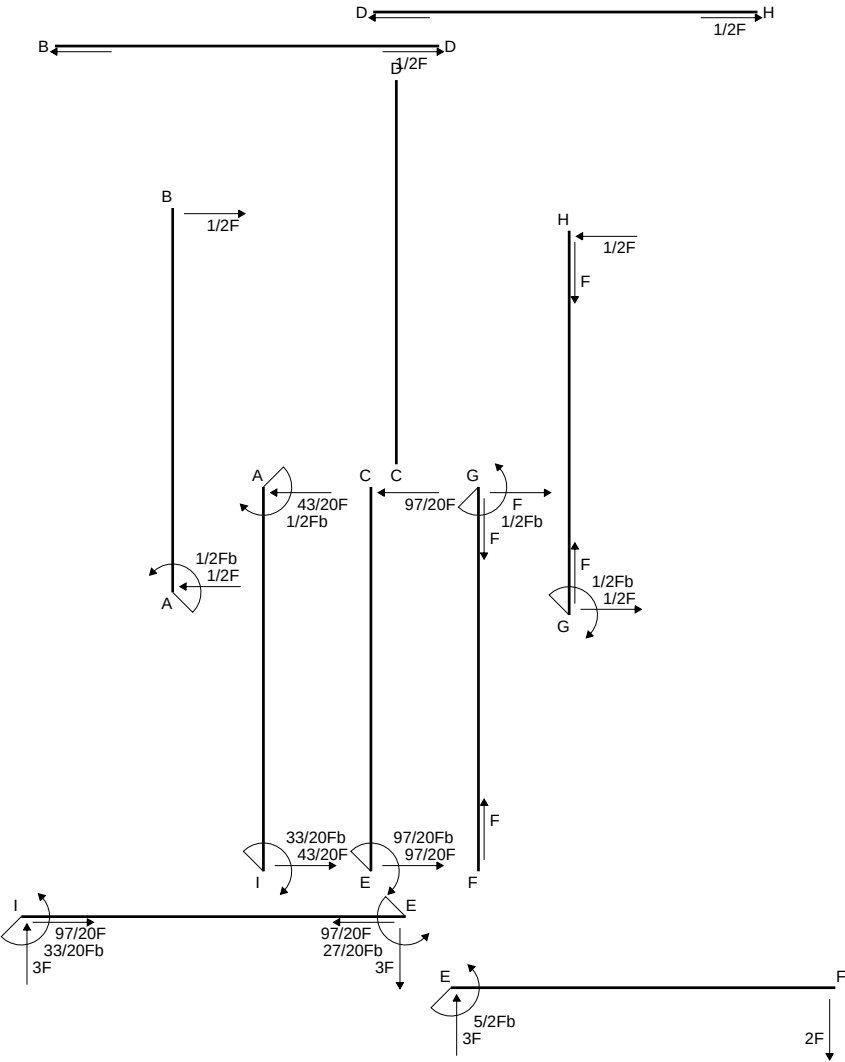
$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

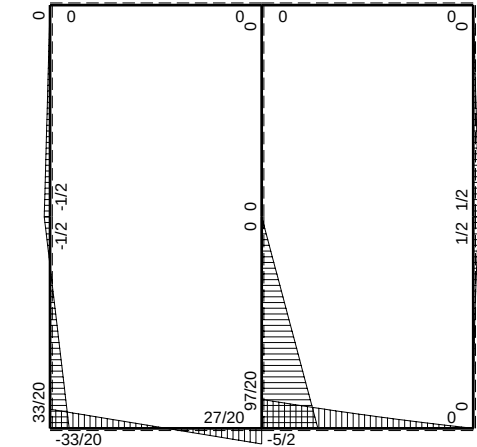


$$\begin{aligned} A &= 996. \text{ mm}^2 \\ J_u &= 275589. \text{ mm}^4 \\ J_v &= 81072. \text{ mm}^4 \\ y_g &= 30.15 \text{ mm} \\ T_y &= 2200. \text{ N} \\ M_x &= -2090000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.15 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.7 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -20.15 \text{ mm} \\ \sigma_c &= -Mv/J_u = -152.8 \text{ N/mm}^2 \\ \tau_c &= 3.308 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 152.9 \text{ N/mm}^2 \\ S &= 4973. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

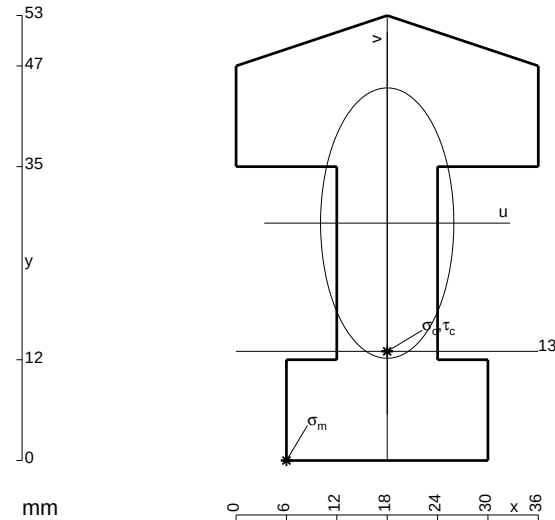
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1104. \text{ mm}^2$$

$$J_u = 286555. \text{ mm}^4$$

$$J_v = 69624. \text{ mm}^4$$

$$y_g = 28.28 \text{ mm}$$

$$T_y = 2910. \text{ N}$$

$$M_x = -2425000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.28 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.3 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

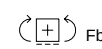
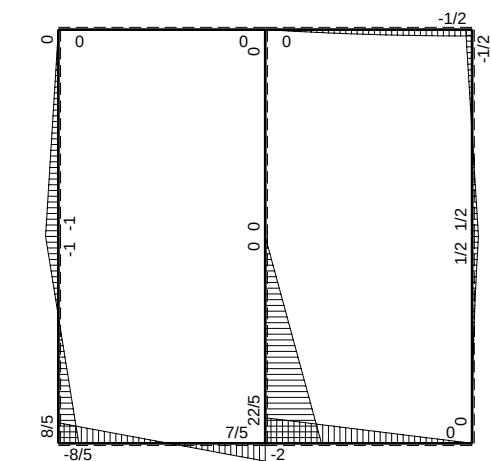
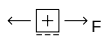
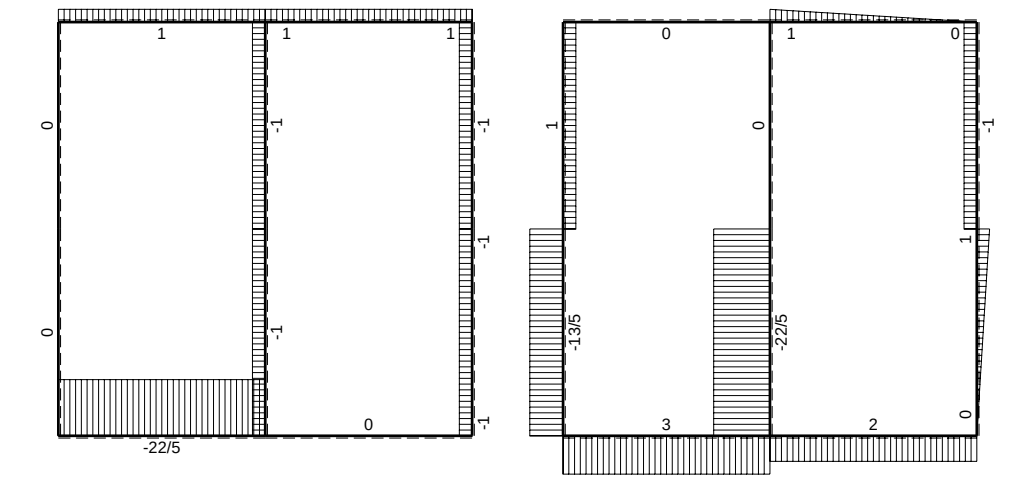
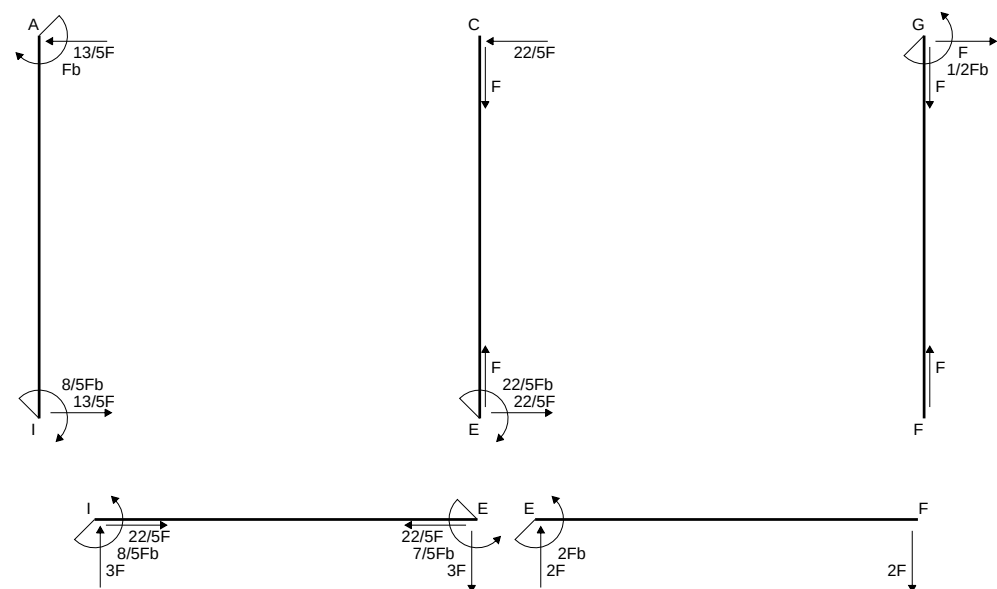
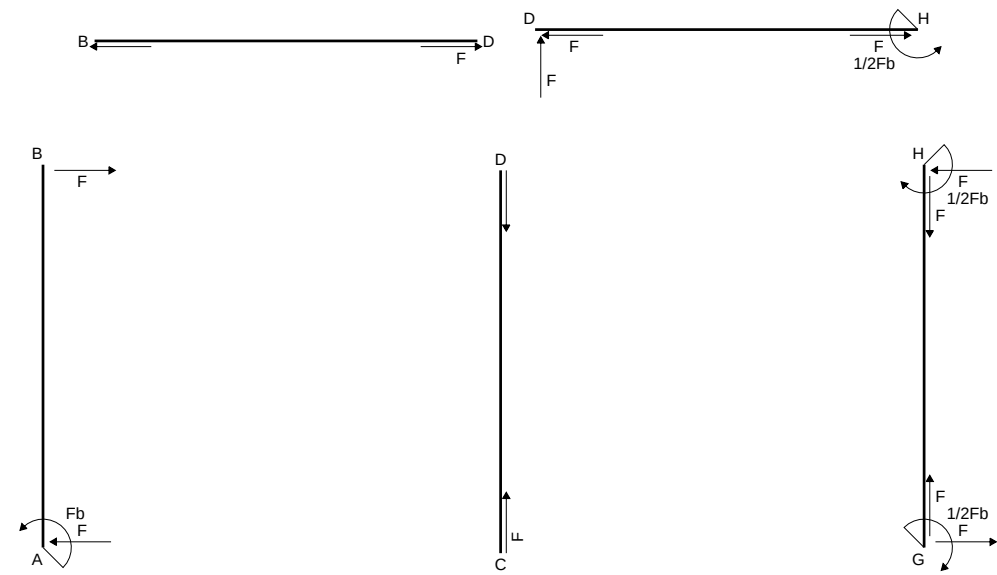
$$v_c = -15.28 \text{ mm}$$

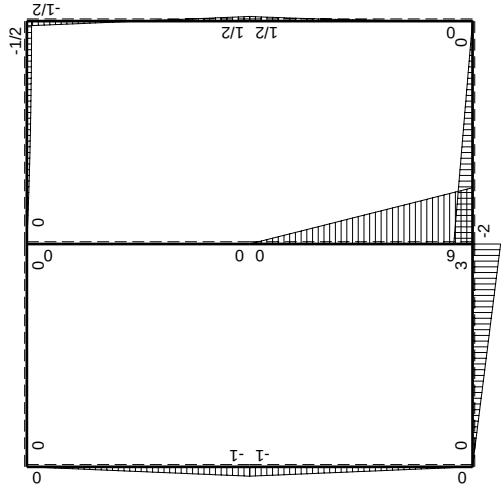
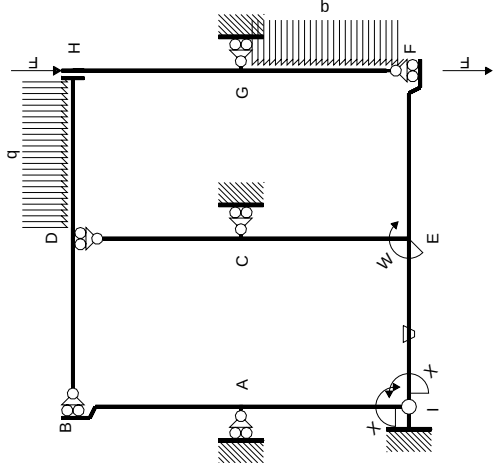
$$\sigma_c = -Mv/J_u = -129.3 \text{ N/mm}^2$$

$$\tau_c = 5.59 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 129.6 \text{ N/mm}^2$$

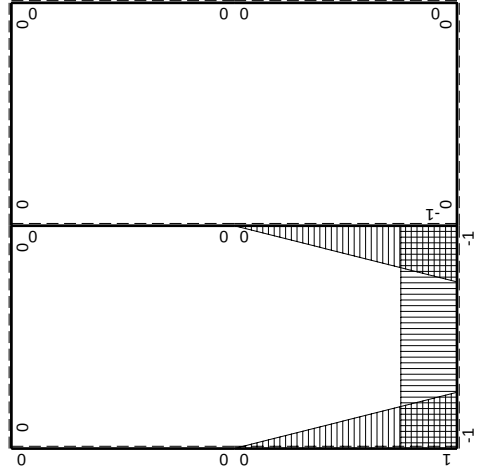
$$S = 6605. \text{ mm}^3$$





Schema di calcolo iperstatico

$\left(\begin{array}{c} \oplus \\ \ominus \end{array} \right) M_0$ flessione da carichi assegnati



$\left(\begin{array}{c} \oplus \\ \ominus \end{array} \right) M_x$ flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

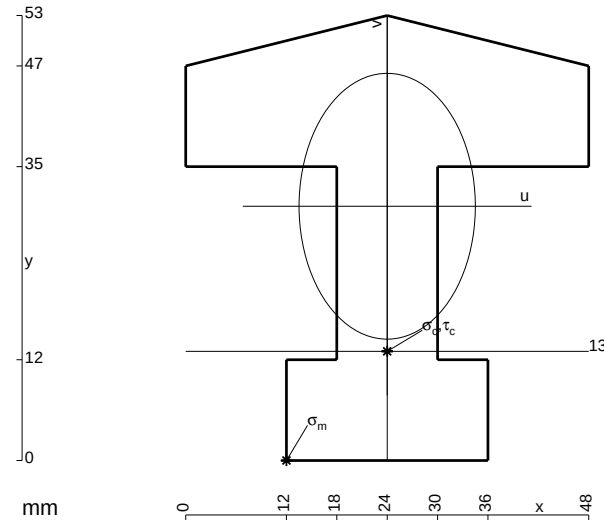
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1284. \text{ mm}^2$$

$$J_u = 321948. \text{ mm}^4$$

$$J_v = 141552. \text{ mm}^4$$

$$y_g = 30.28 \text{ mm}$$

$$T_y = 4000. \text{ N}$$

$$M_x = -2120000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.28 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.4 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 13. \text{ mm}$$

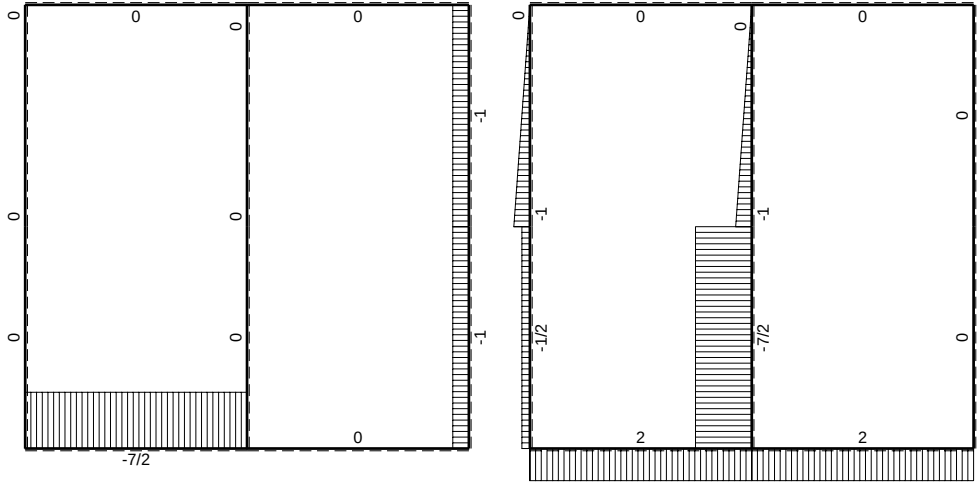
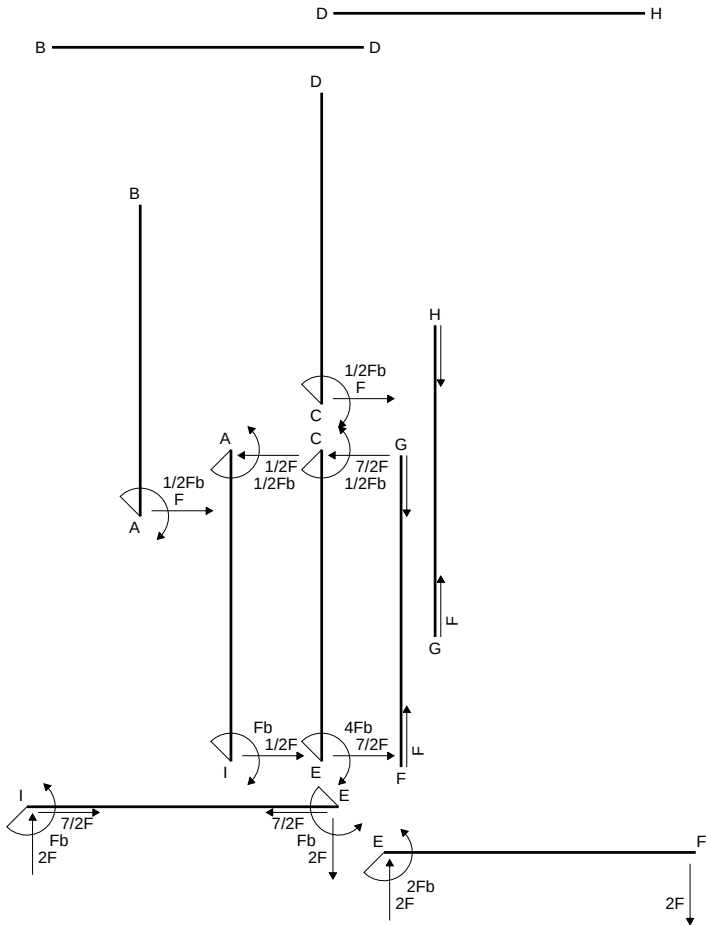
$$v_c = -17.28 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -113.8 \text{ N/mm}^2$$

$$\tau_c = 7.462 \text{ N/mm}^2$$

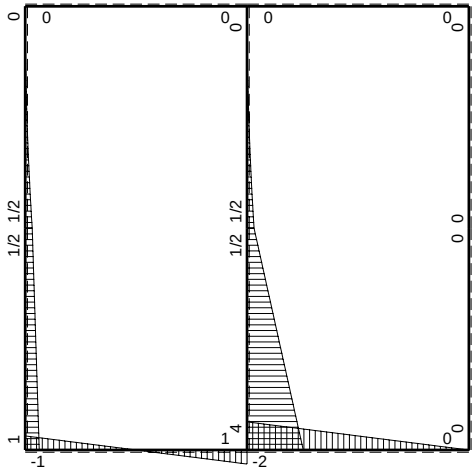
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 114.6 \text{ N/mm}^2$$

$$S = 7208. \text{ mm}^3$$

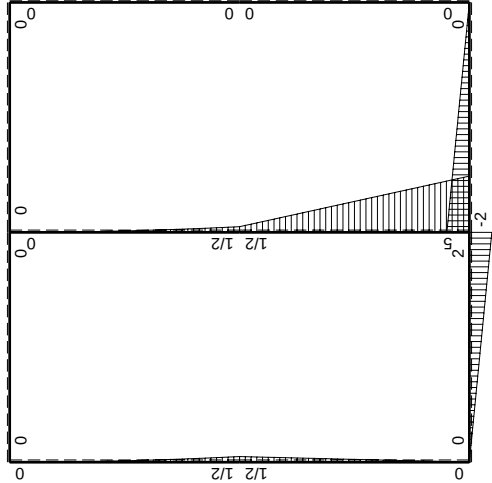
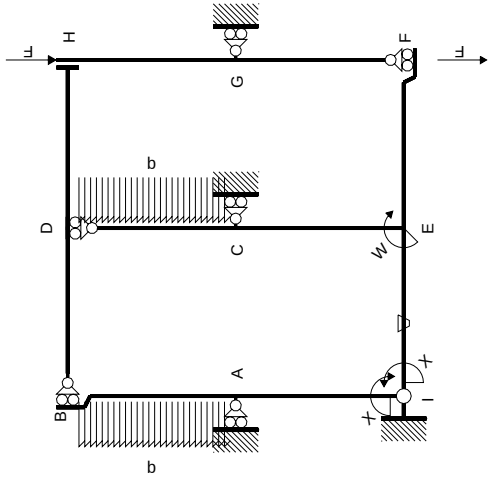


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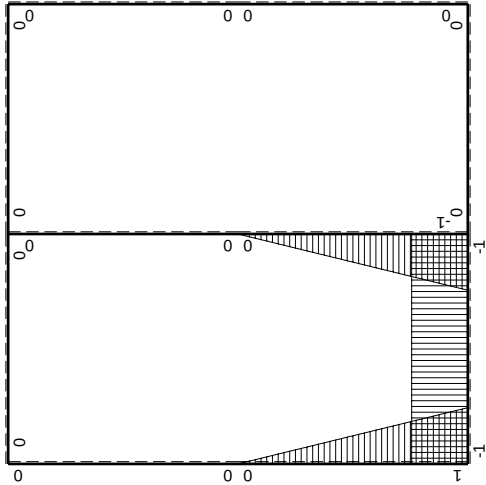


⊕ ⊕ Fb



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2 qx^2$	0	0	0	0		
CD b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2 qx^2$	0	0	0	0		
EF b	0	$-2Fb + 2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 19/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

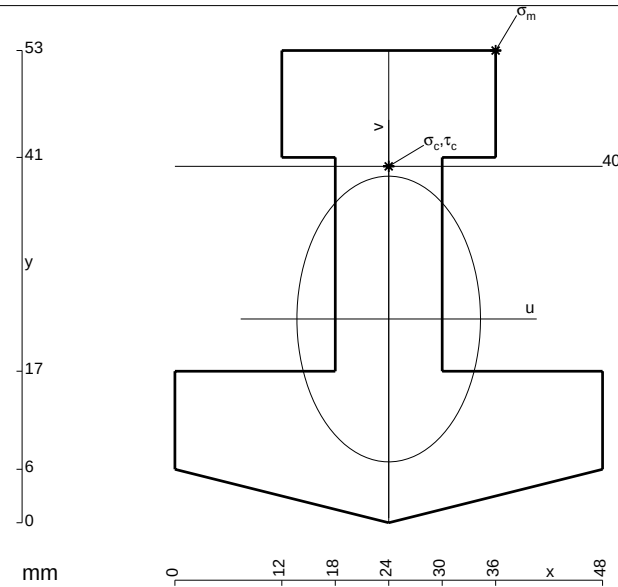
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 1248. \text{ mm}^2$$

$$J_u = 320937. \text{ mm}^4$$

$$J_v = 132480. \text{ mm}^4$$

$$y_g = 22.87 \text{ mm}$$

$$T_y = 3840. \text{ N}$$

$$M_x = -2227200. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.13 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 209.1 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

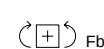
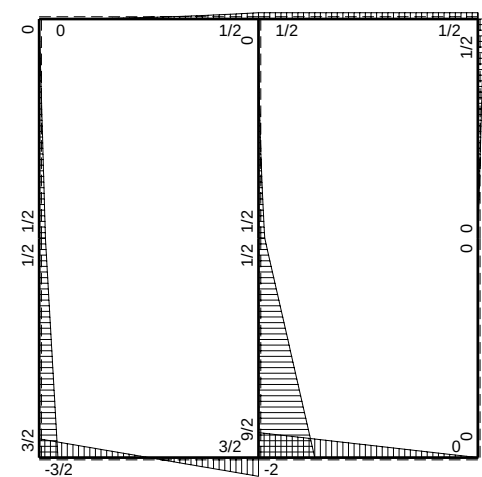
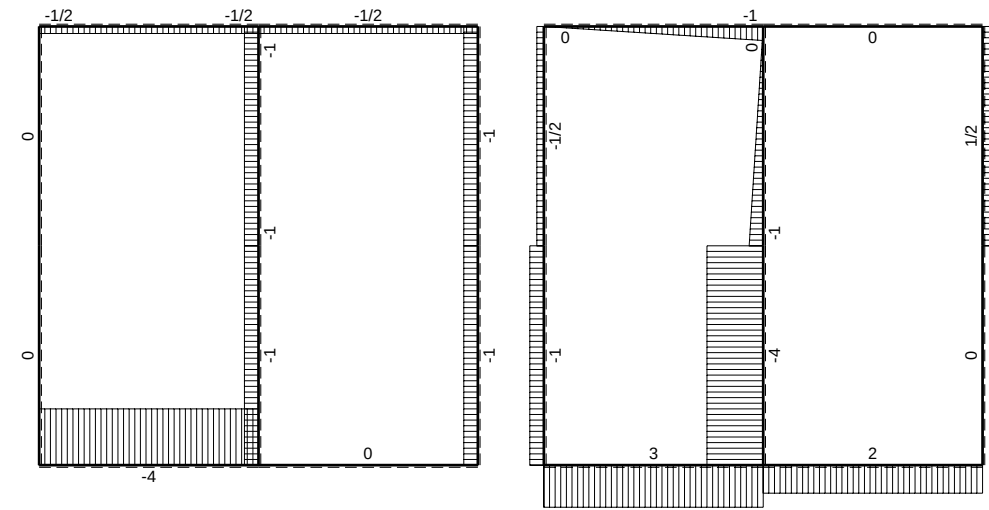
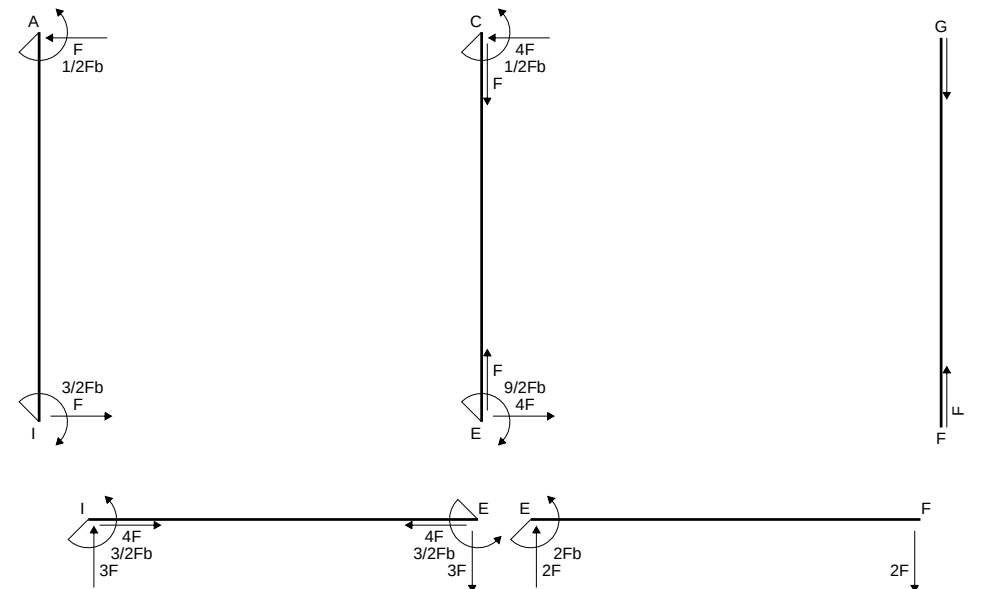
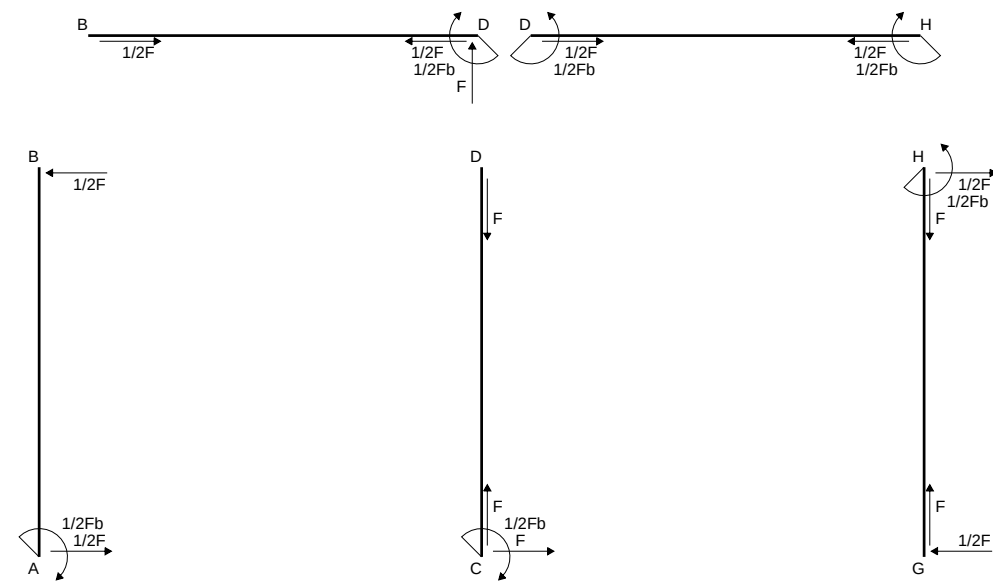
$$v_c = 17.13 \text{ mm}$$

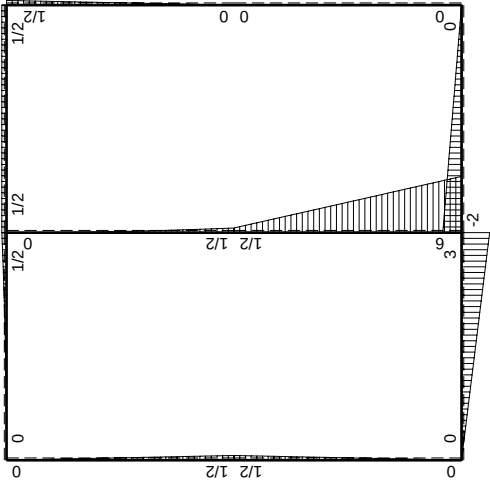
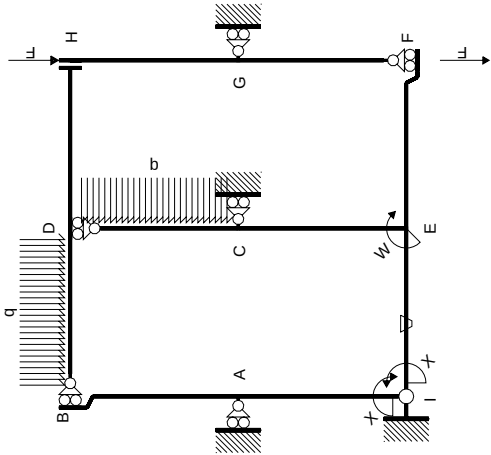
$$\sigma_c = -Mv/J_u = 118.9 \text{ N/mm}^2$$

$$\tau_c = 7.141 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 119.6 \text{ N/mm}^2$$

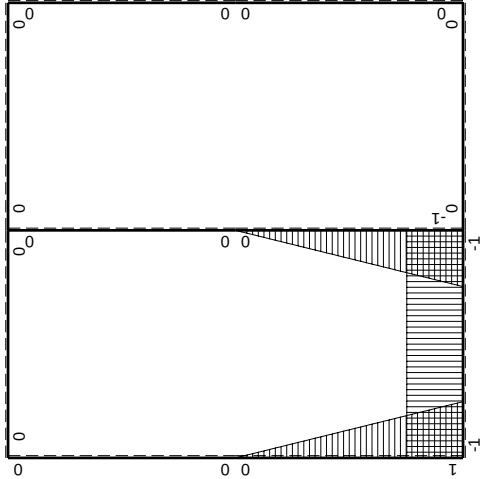
$$S = 7162. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-11/2Fx$	0	$-6Fb+23/2Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-25/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-11/2Fx$	0	$-1/2Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 23/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 23/4 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 23/4 b - 11/6 b) Fb \frac{1}{EJ} = -25/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

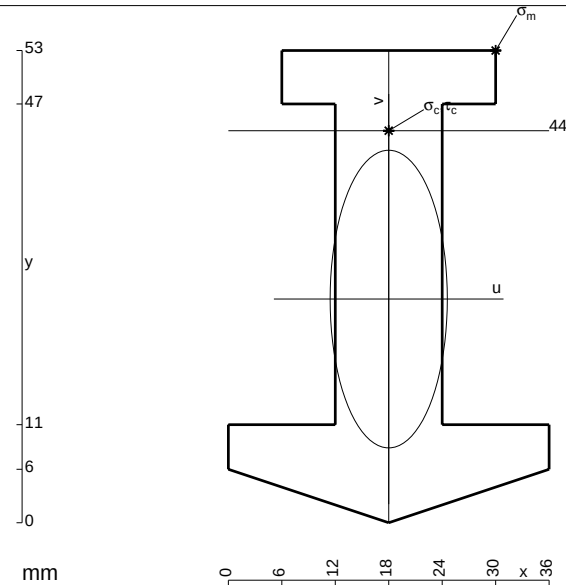
$$= (-1/4 b - 11/6 b) Fb \frac{1}{EJ} = -25/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 864. \text{ mm}^2$$

$$J_u = 241215. \text{ mm}^4$$

$$J_v = 37368. \text{ mm}^4$$

$$y_g = 25.1 \text{ mm}$$

$$T_y = 3000. \text{ N}$$

$$M_x = -1890000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 27.9 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 218.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

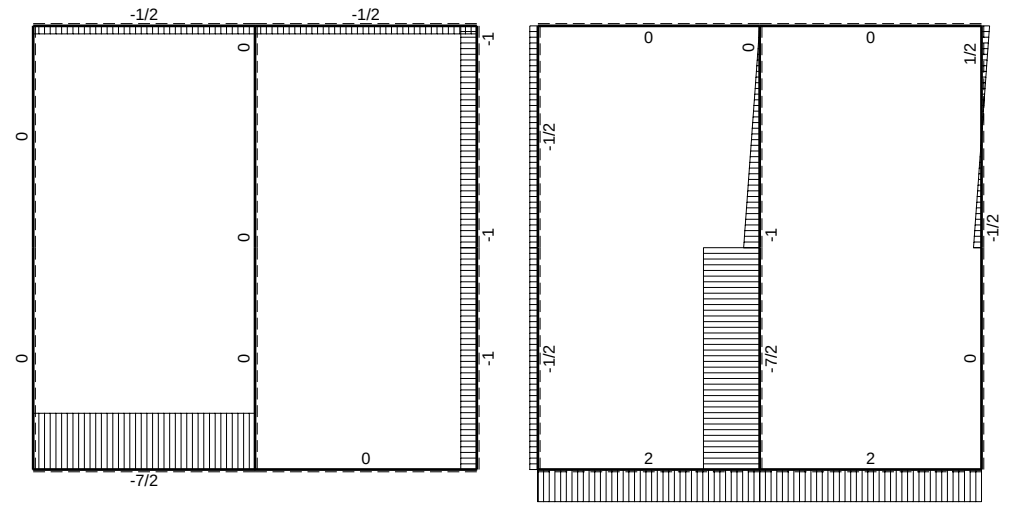
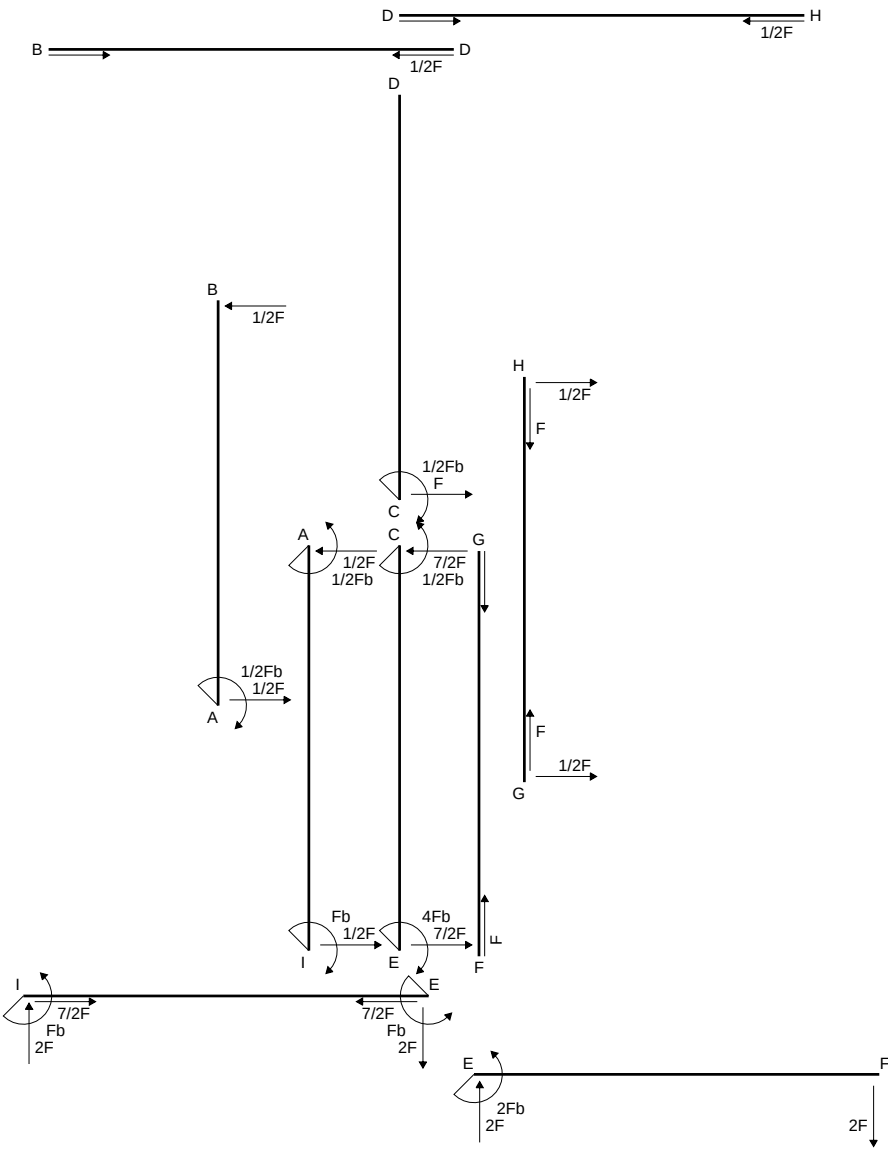
$$v_c = 18.9 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 148.1 \text{ N/mm}^2$$

$$\tau_c = 4.477 \text{ N/mm}^2$$

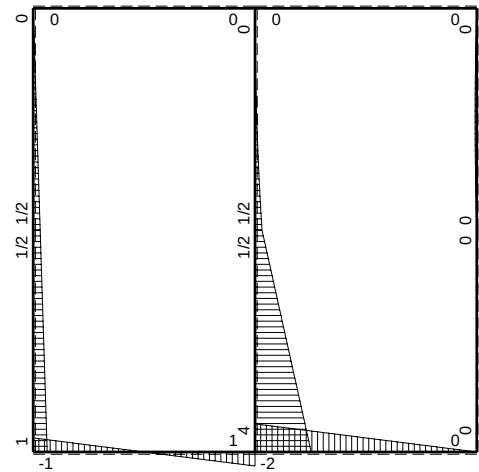
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 148.3 \text{ N/mm}^2$$

$$S = 4319. \text{ mm}^3$$

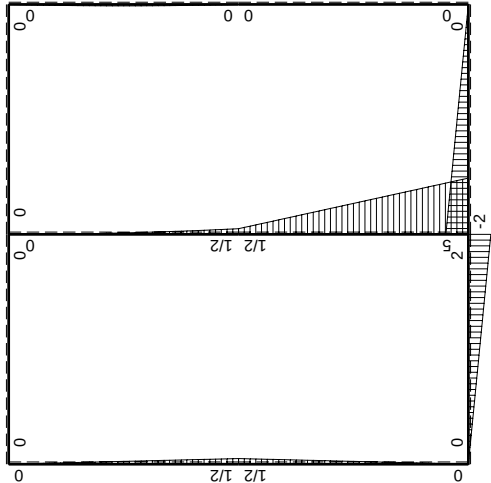
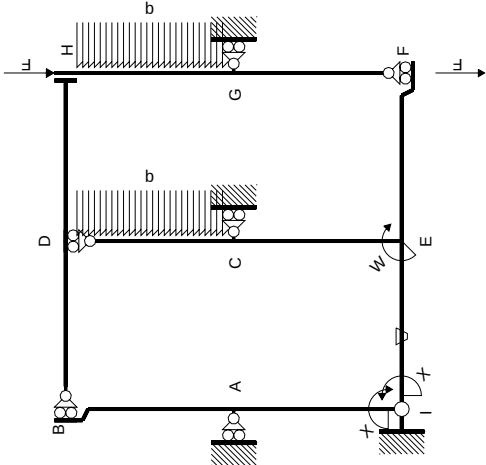


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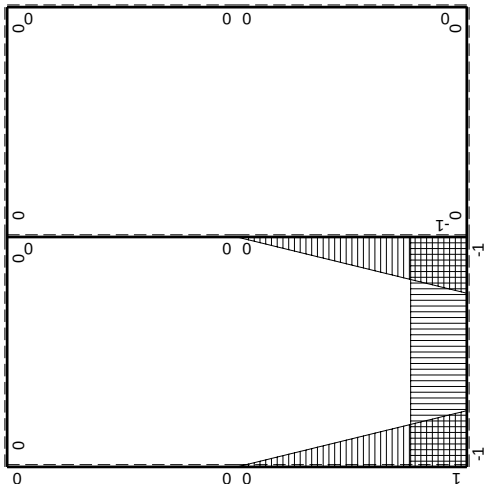


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-5/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 19/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

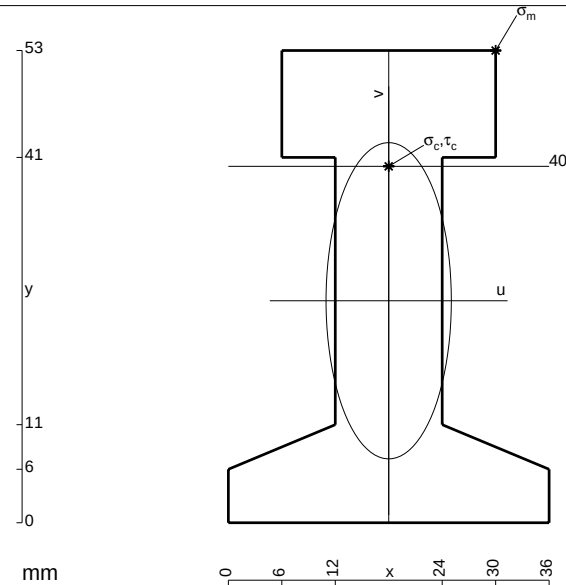
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 984. \text{ mm}^2$$

$$J_u = 309963. \text{ mm}^4$$

$$J_v = 48672. \text{ mm}^4$$

$$y_g = 24.91 \text{ mm}$$

$$T_y = 3720. \text{ N}$$

$$M_x = -2529600. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.09 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.2 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

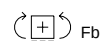
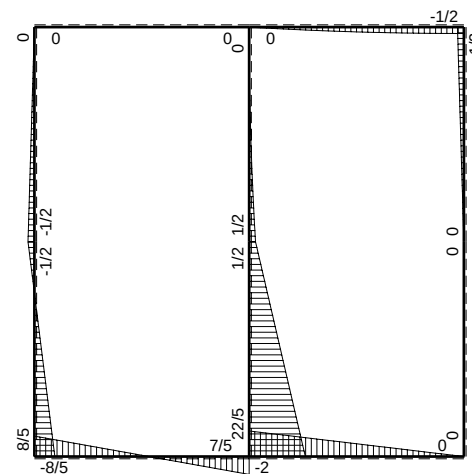
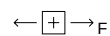
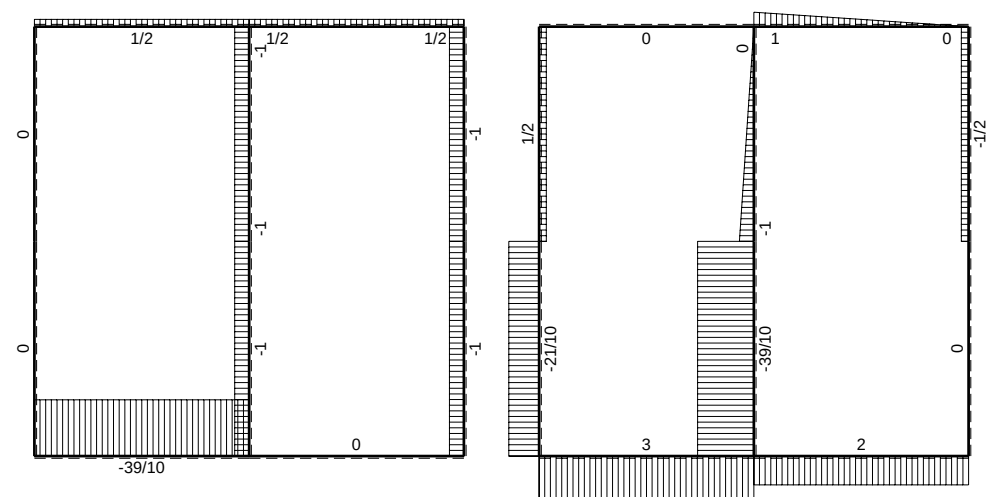
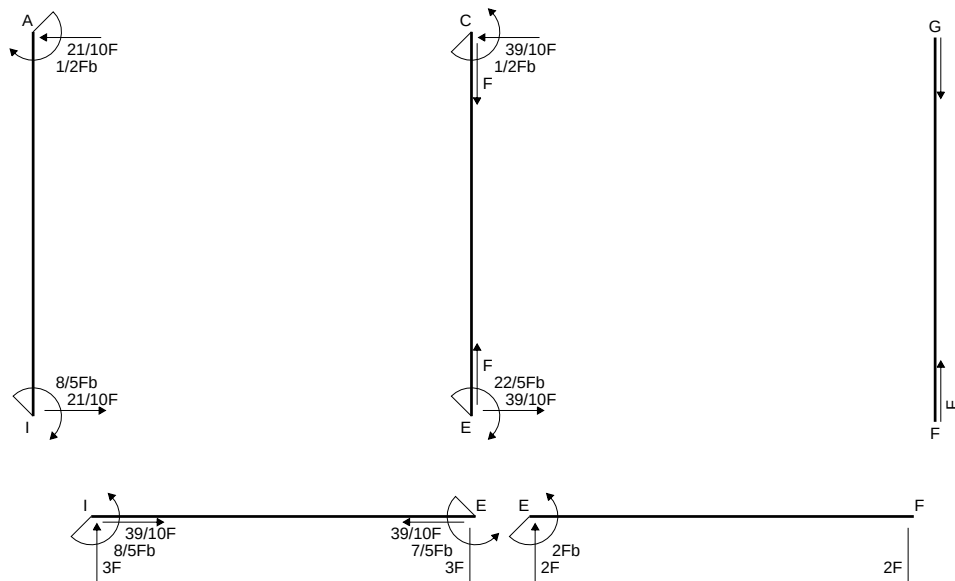
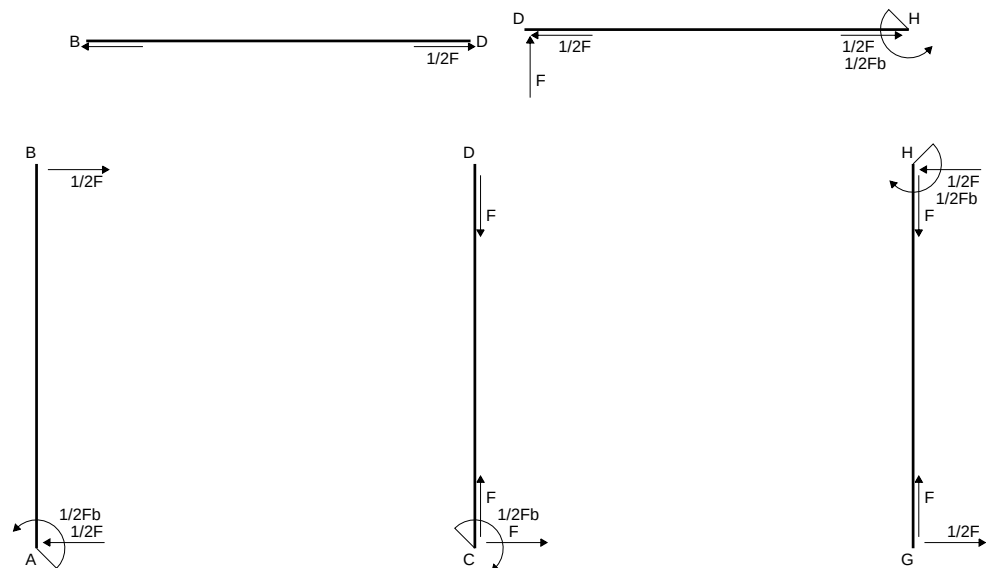
$$v_c = 15.09 \text{ mm}$$

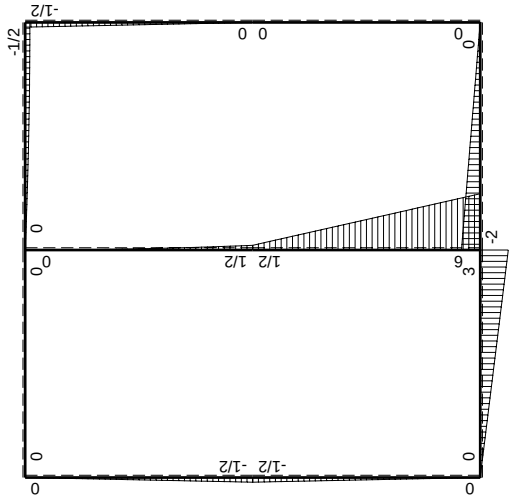
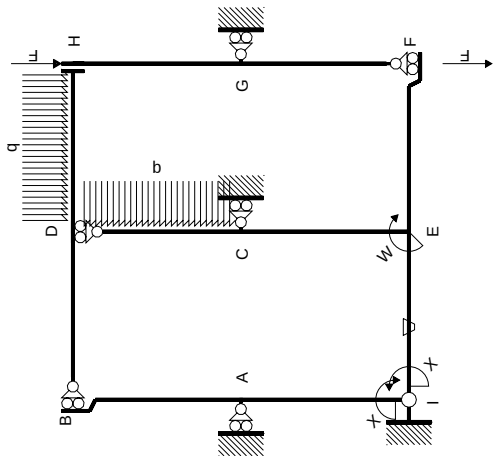
$$\sigma_c = -Mv/J_u = 123.1 \text{ N/mm}^2$$

$$\tau_c = 6.549 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 123.6 \text{ N/mm}^2$$

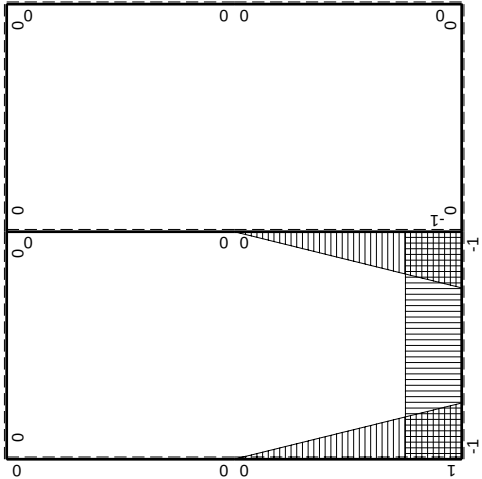
$$S = 6548. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-11/2Fx$	0	$-6Fb+23/2Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-25/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-11/2Fx$	0	$-1/2Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-8/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$8/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 23/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 23/4 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 23/4 b - 11/6 b) Fb \frac{1}{EJ} = -25/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

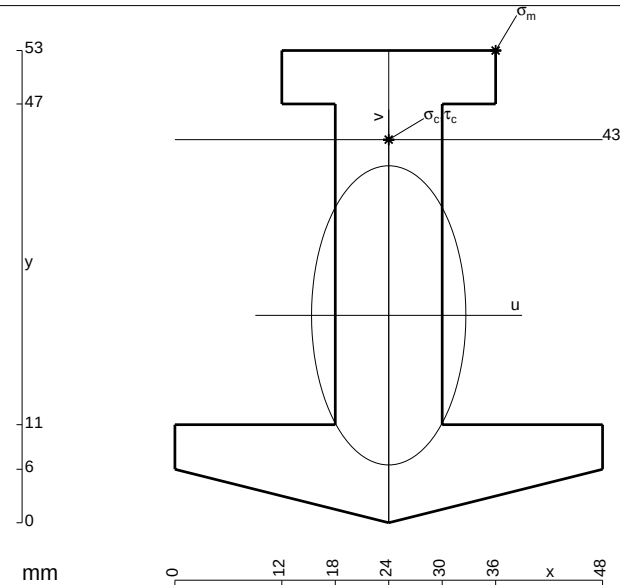
$$= (-1/4 b - 11/6 b) Fb \frac{1}{EJ} = -25/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 960. \text{ mm}^2$$

$$J_u = 270775. \text{ mm}^4$$

$$J_v = 72000. \text{ mm}^4$$

$$y_g = 23.27 \text{ mm}$$

$$T_y = 2940. \text{ N}$$

$$M_x = -2175600. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 29.73 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

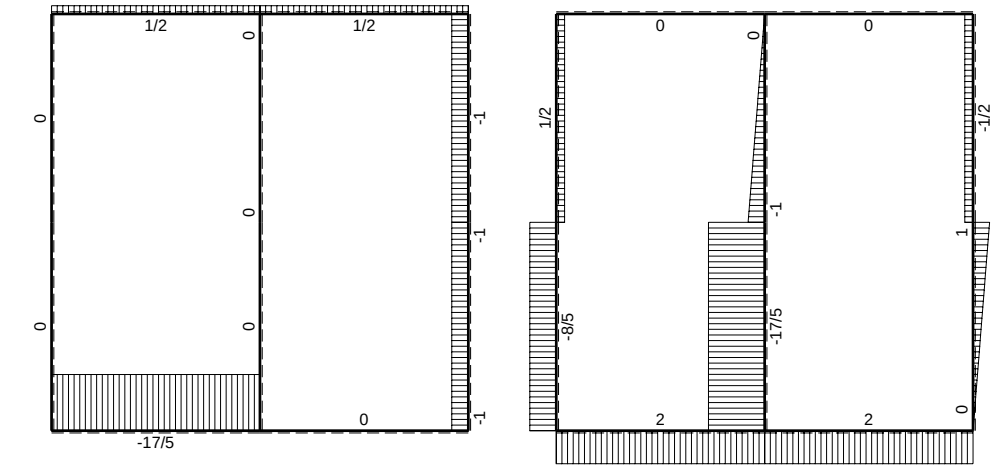
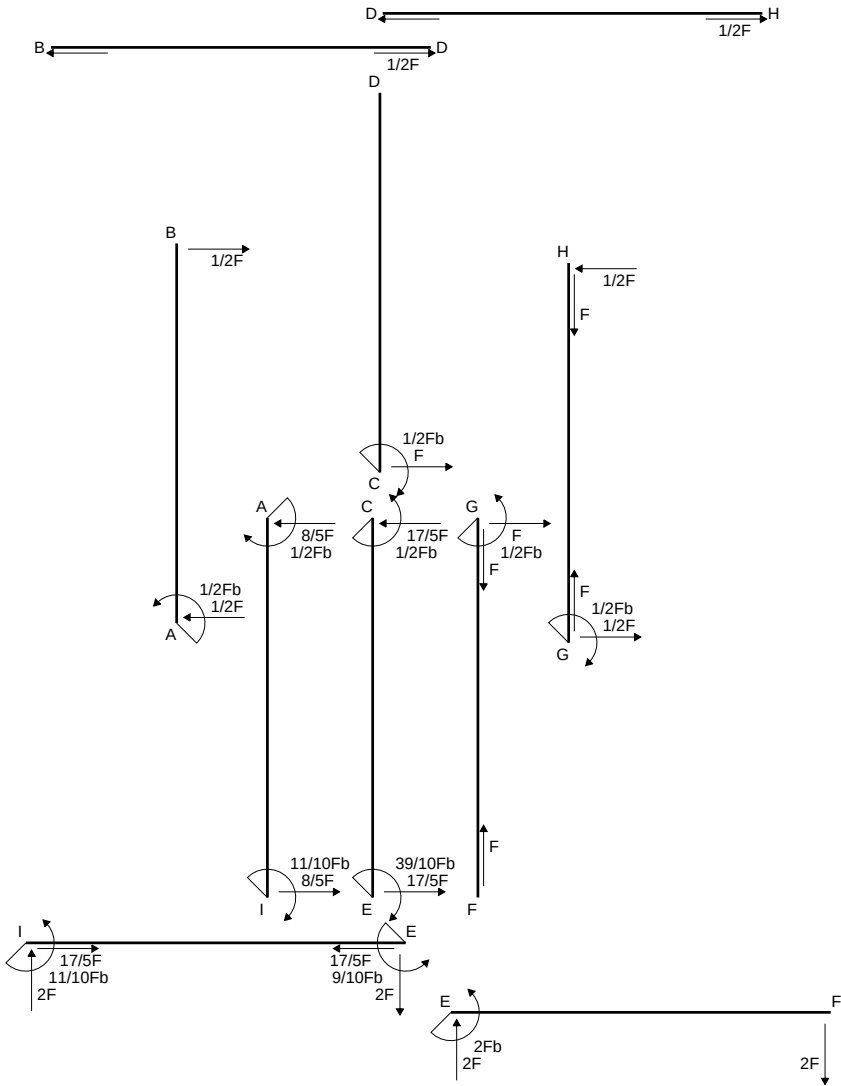
$$v_c = 19.73 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 158.5 \text{ N/mm}^2$$

$$\tau_c = 4.426 \text{ N/mm}^2$$

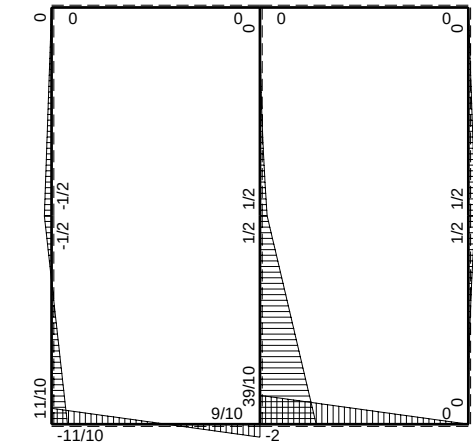
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 158.7 \text{ N/mm}^2$$

$$S = 4891. \text{ mm}^3$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-9/2Fx$	0	$-5Fb+19/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-1/2Fb-9/2Fx$	0	$-1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-5 + 19/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 19/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 19/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

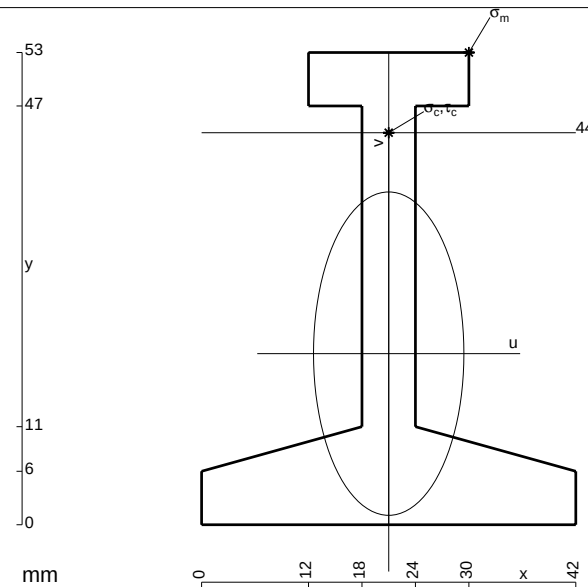
$$= (-1/4 b - 3/2 b) Fb \frac{1}{EJ} = -7/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

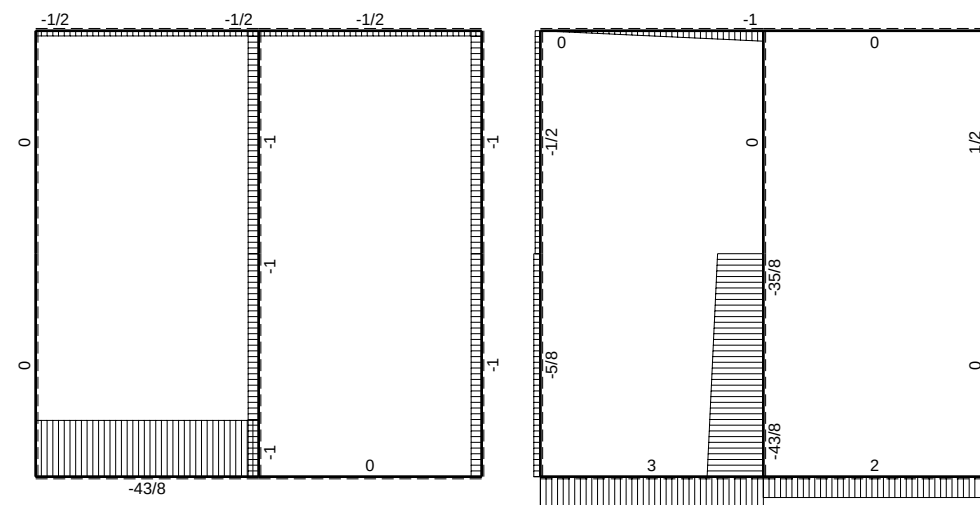
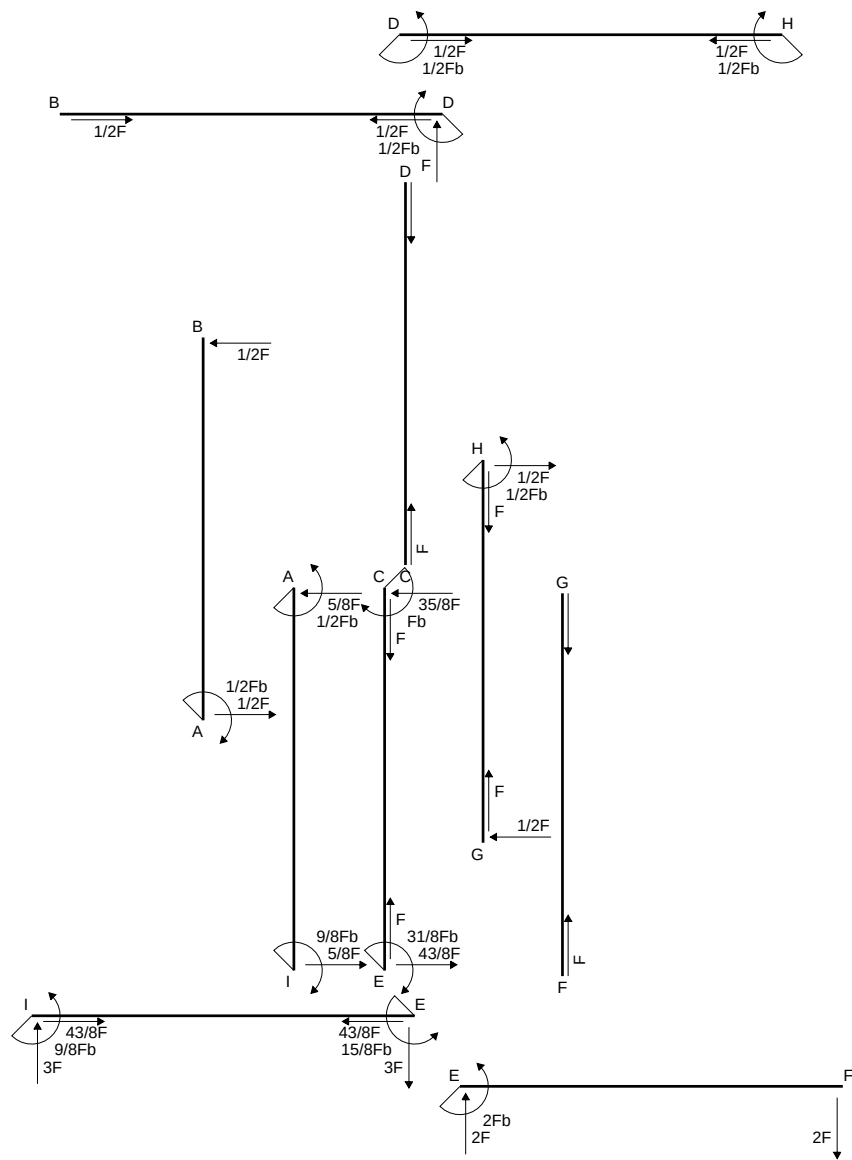
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

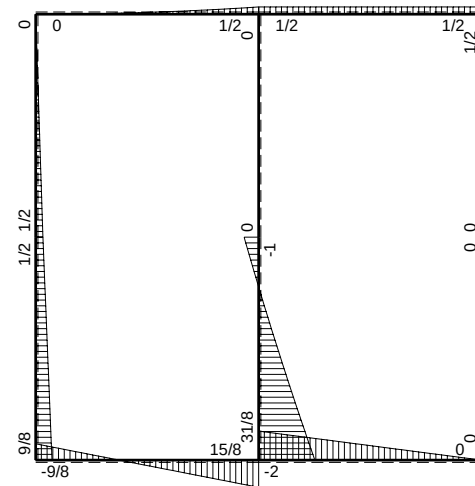
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

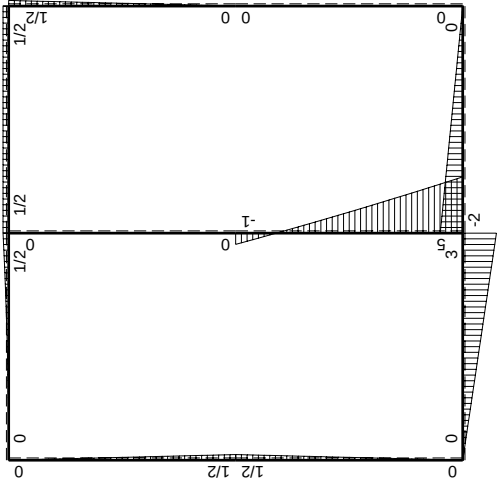
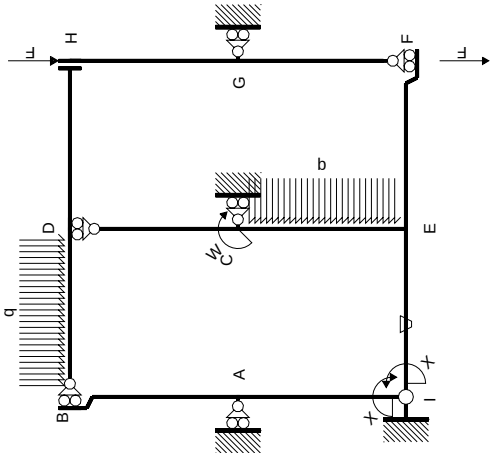


$$\begin{aligned} A &= 696. \text{ mm}^2 \\ J_u &= 229334. \text{ mm}^4 \\ J_v &= 49608. \text{ mm}^4 \\ y_g &= 19.2 \text{ mm} \\ T_y &= 1700. \text{ N} \\ M_x &= -1343000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 33.8 \text{ mm} \\ \sigma_m &= -Mv/J_u = 197.9 \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 24.8 \text{ mm} \\ \sigma_c &= -Mv/J_u = 145.2 \text{ N/mm}^2 \\ \tau_c &= 4.694 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 145.4 \text{ N/mm}^2 \\ S &= 3799. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow \mathbb{F}$$

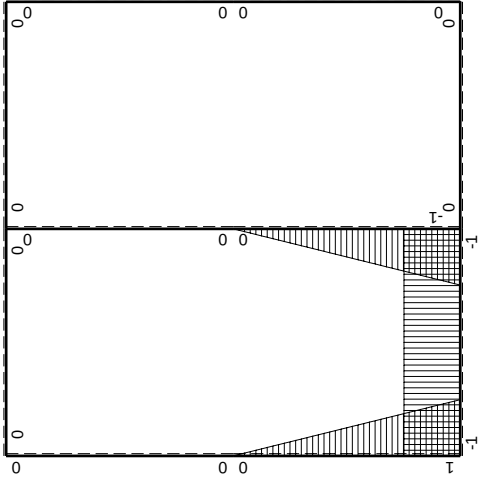
$\uparrow \boxed{+} \downarrow F$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-13/2Fx+1/2qx^2$	0	$-5Fb+23/2Fx-7Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-35/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-11/2Fx-1/2qx^2$	0	$Fx-11/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-15/8Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 23/2 x/b - 7x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= \left[-5x + 23/4 x^2/b - 7/3 x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 23/4 b - 7/3 b + 1/8 b) Fb \frac{1}{EJ} = -35/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 11/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 11/6 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

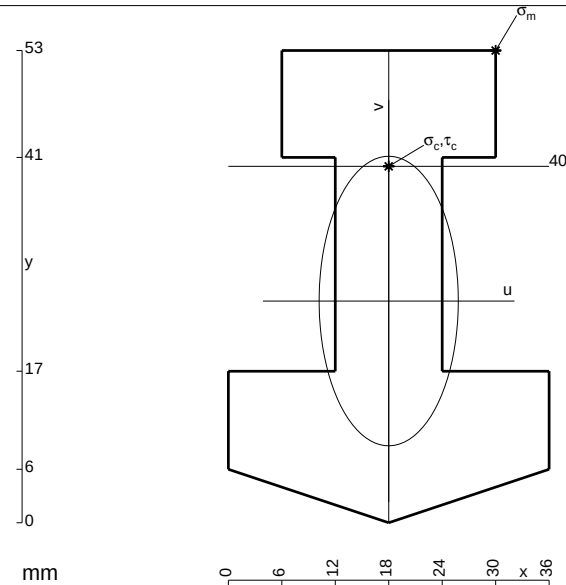
$$= (1/2 b - 11/6 b - 1/8 b) Fb \frac{1}{EJ} = -35/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 1080. \text{ mm}^2$$

$$J_u = 285273. \text{ mm}^4$$

$$J_v = 65880. \text{ mm}^4$$

$$y_g = 24.88 \text{ mm}$$

$$T_y = 2520. \text{ N}$$

$$M_x = -2116800. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.12 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

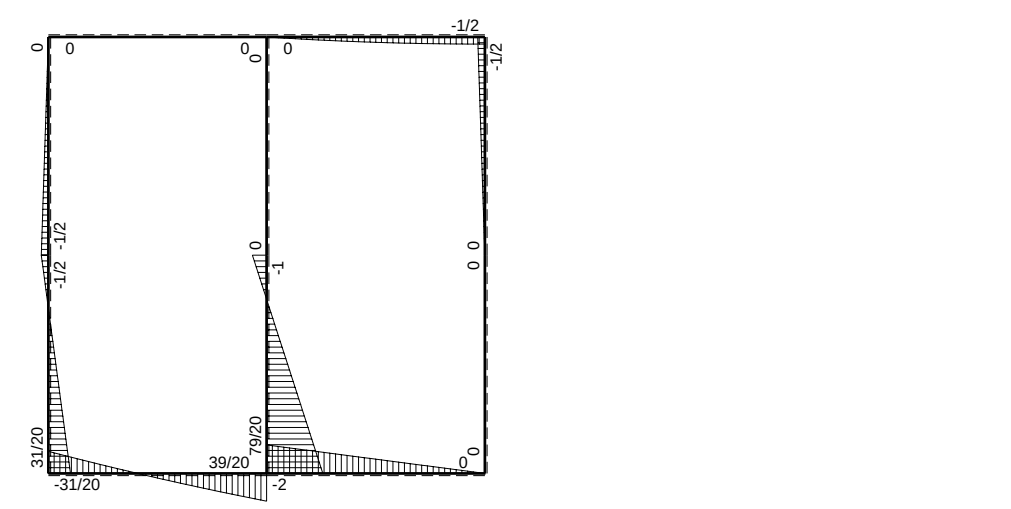
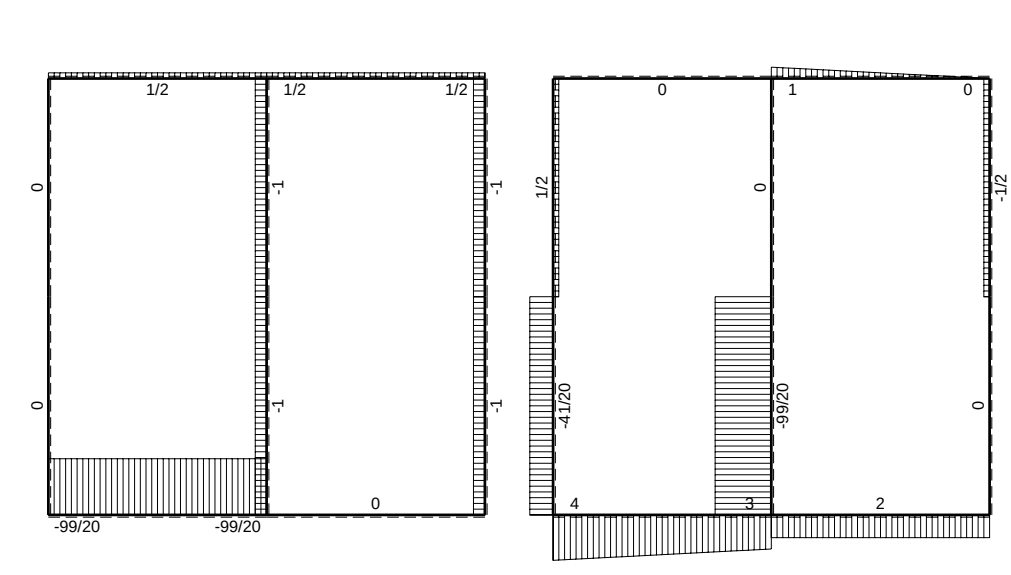
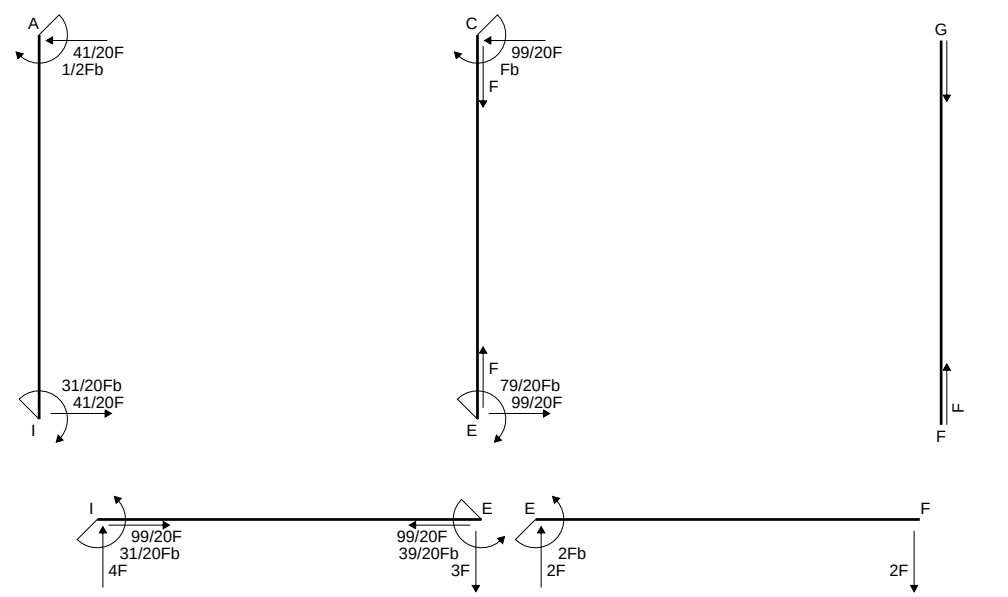
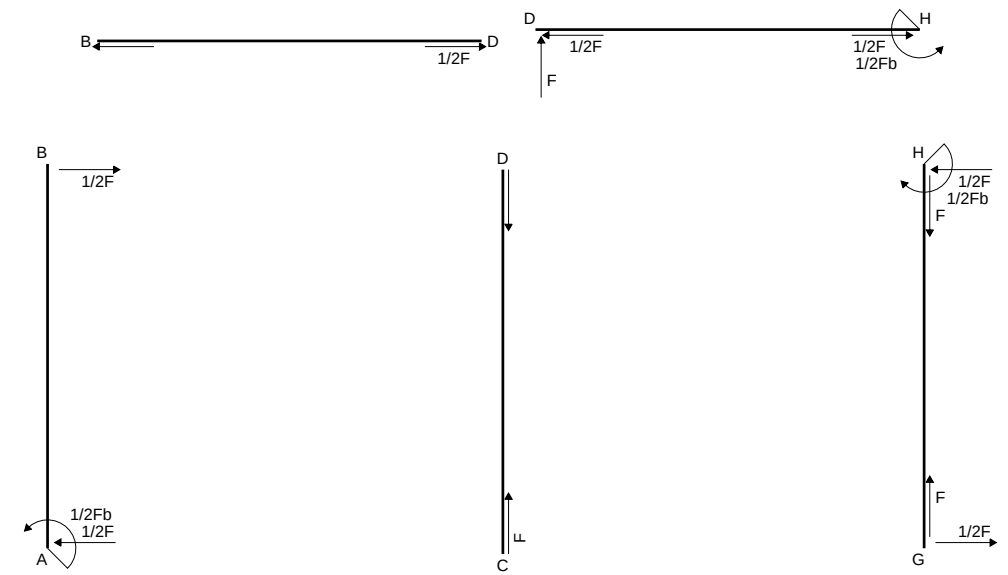
$$v_c = 15.12 \text{ mm}$$

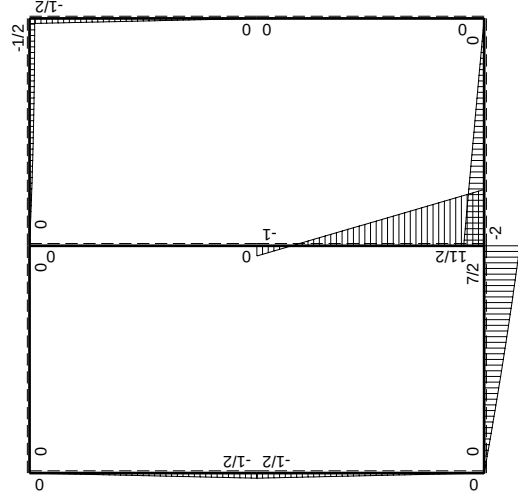
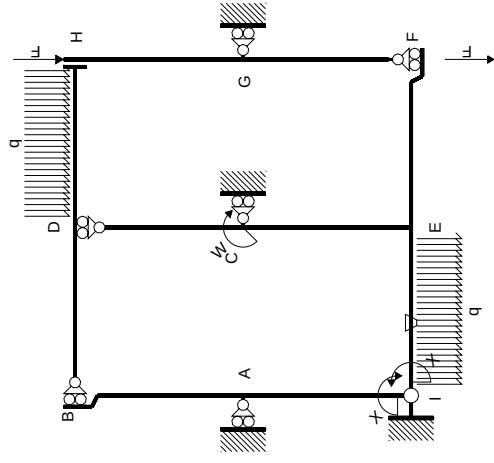
$$\sigma_c = -Mv/J_u = 112.2 \text{ N/mm}^2$$

$$\tau_c = 4.827 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 112.5 \text{ N/mm}^2$$

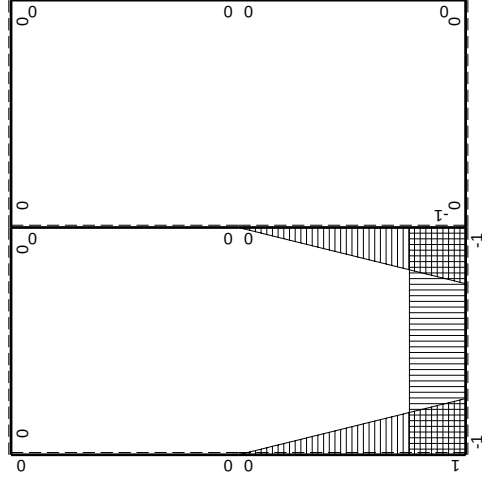
$$S = 6557. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-13/2Fx$	0	$-11/2Fb+12Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-13/2Fx$	0	$Fx-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 12x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 6x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 6b - 13/6 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

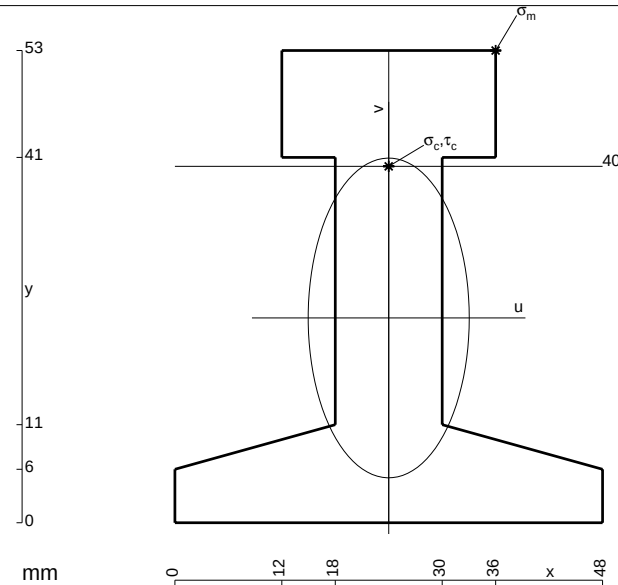
$$= (1/2 b - 13/6 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1086. \text{ mm}^2$$

$$J_u = 349673. \text{ mm}^4$$

$$J_v = 88740. \text{ mm}^4$$

$$y_g = 22.98 \text{ mm}$$

$$T_y = 2840. \text{ N}$$

$$M_x = -2556000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.02 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.4 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

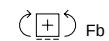
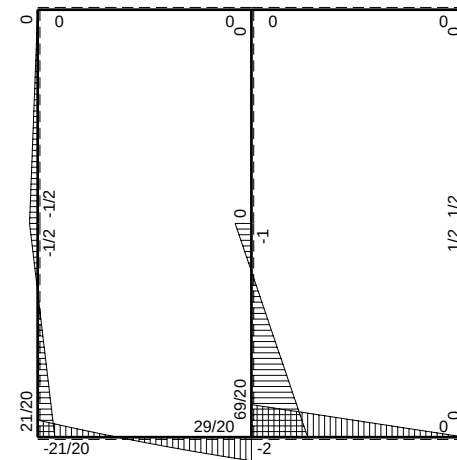
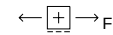
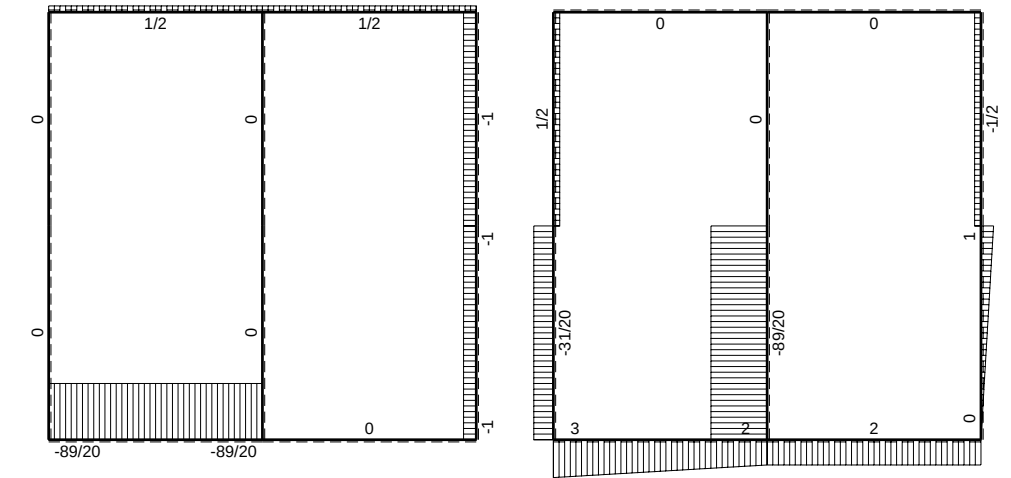
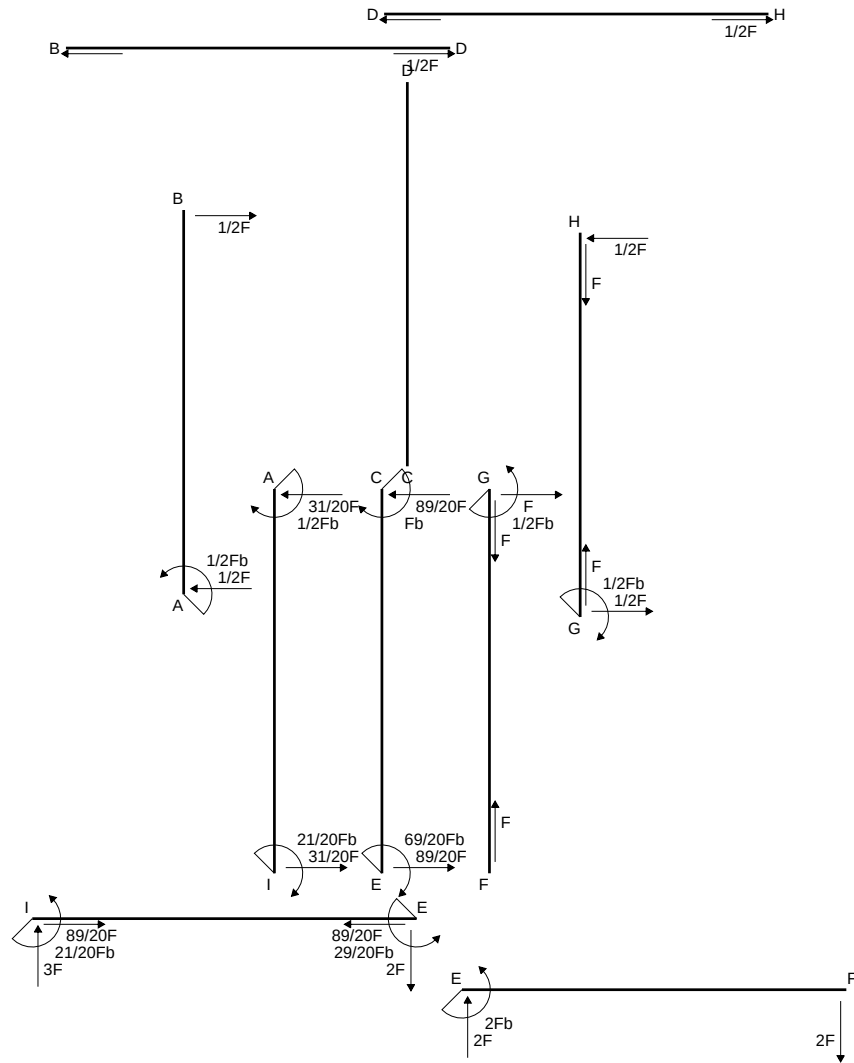
$$v_c = 17.02 \text{ mm}$$

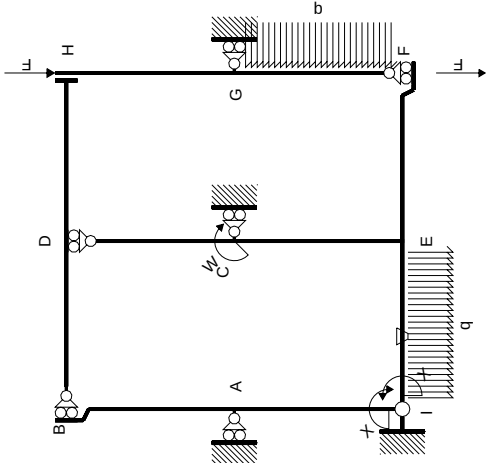
$$\sigma_c = -Mv/J_u = 124.4 \text{ N/mm}^2$$

$$\tau_c = 4.824 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 124.7 \text{ N/mm}^2$$

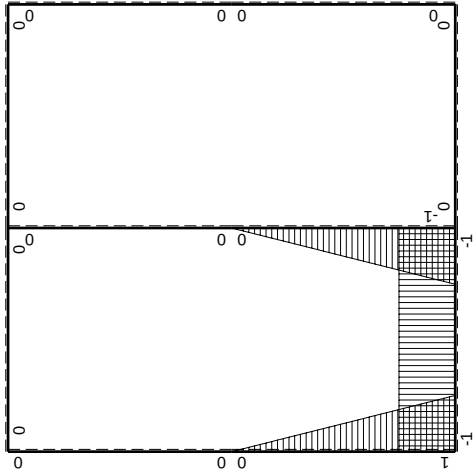
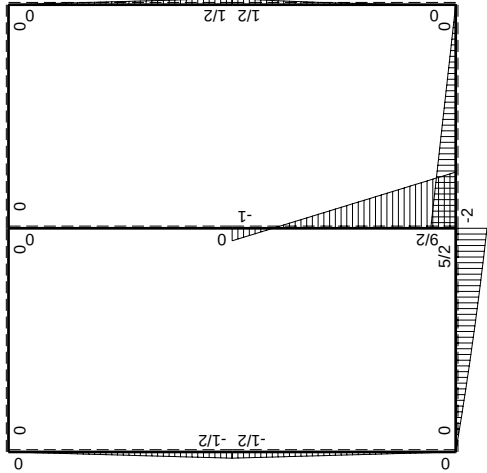
$$S = 7127. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-11/2Fx$	0	$-9/2Fb+10Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-11/2Fx$	0	$Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$21/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 10x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 5x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 5b - 11/6 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

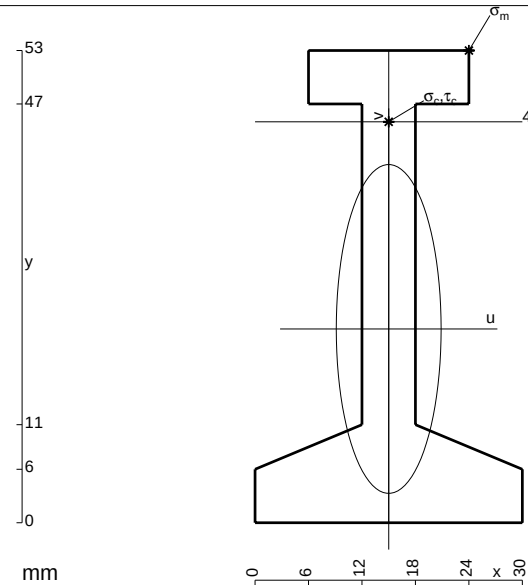
$$= (1/2 b - 11/6 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 594. \text{ mm}^2$$

$$J_u = 202331. \text{ mm}^4$$

$$J_v = 20574. \text{ mm}^4$$

$$y_g = 21.75 \text{ mm}$$

$$T_y = 1560. \text{ N}$$

$$M_x = -1482000. \text{ Nmm}$$

$$x_m = 24. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 31.25 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 228.9 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 45. \text{ mm}$$

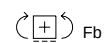
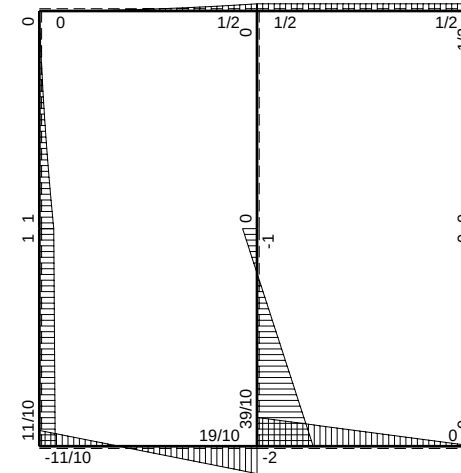
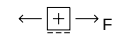
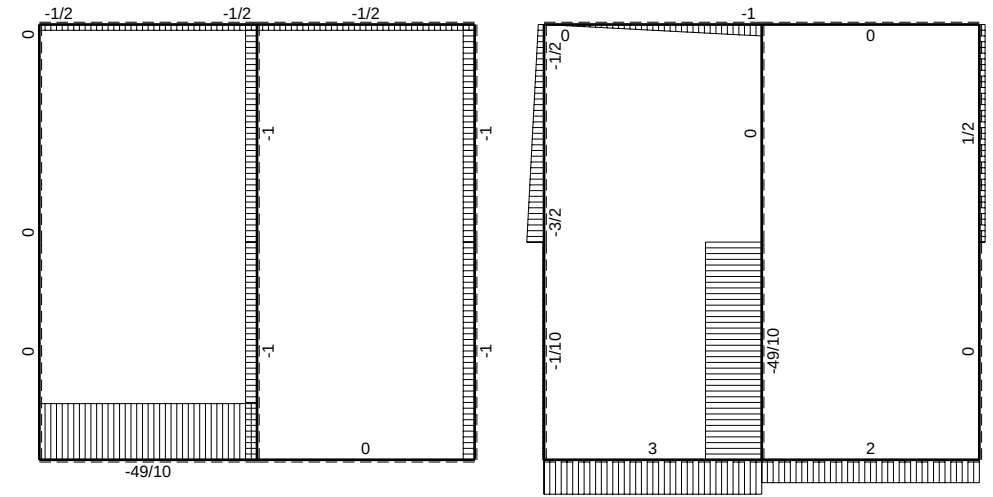
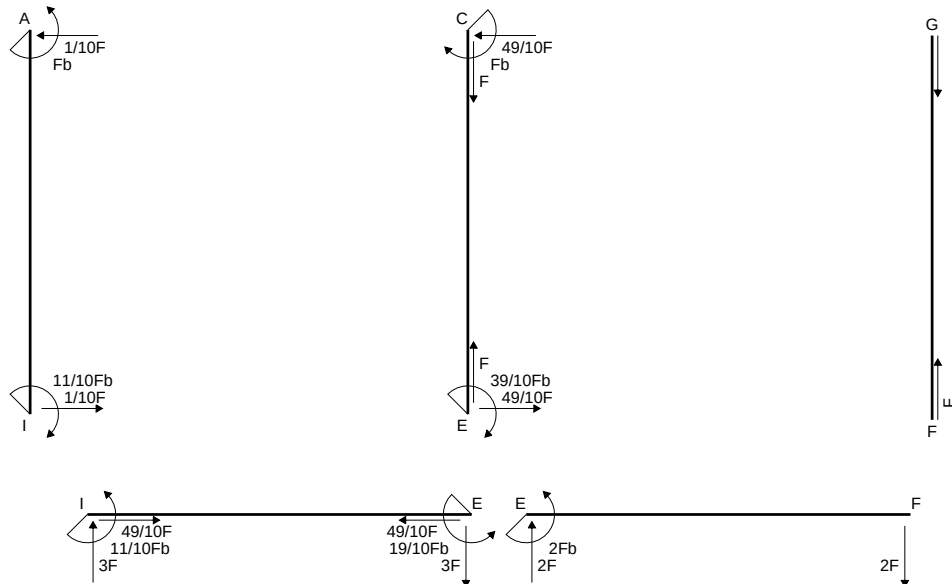
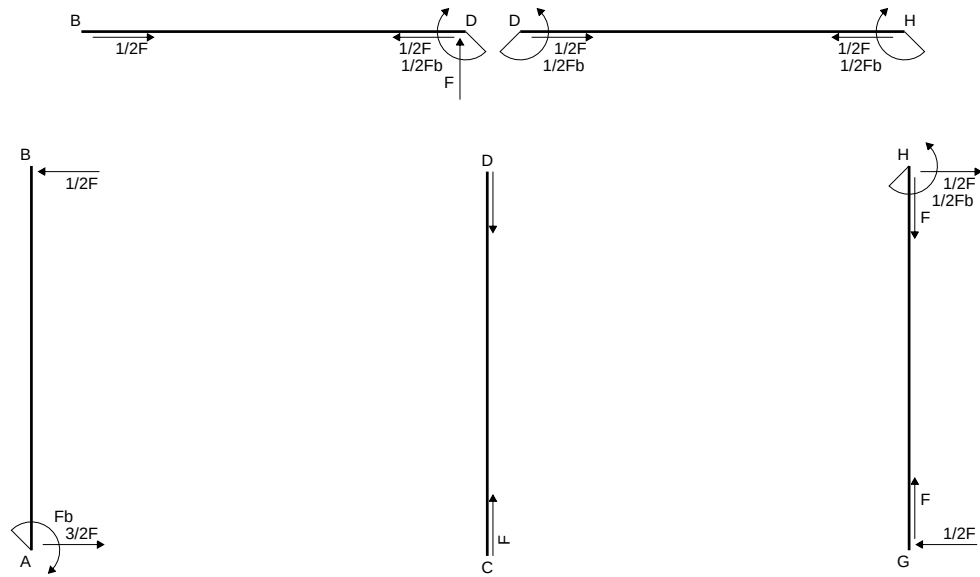
$$v_c = 23.25 \text{ mm}$$

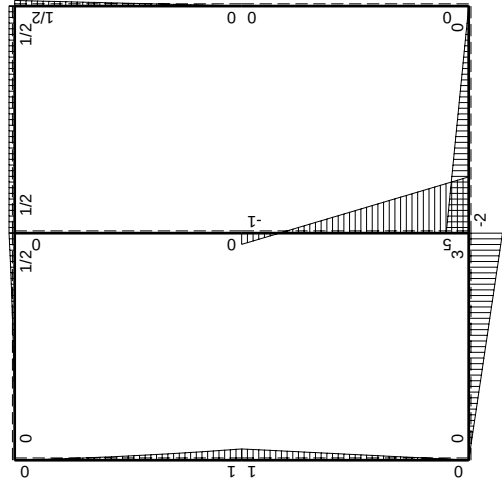
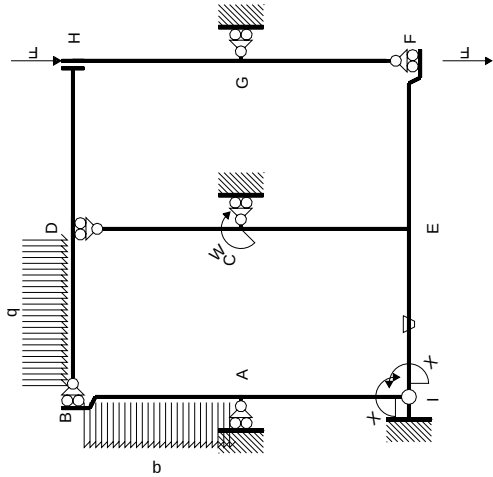
$$\sigma_c = -Mv/J_u = 170.3 \text{ N/mm}^2$$

$$\tau_c = 4.295 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 170.5 \text{ N/mm}^2$$

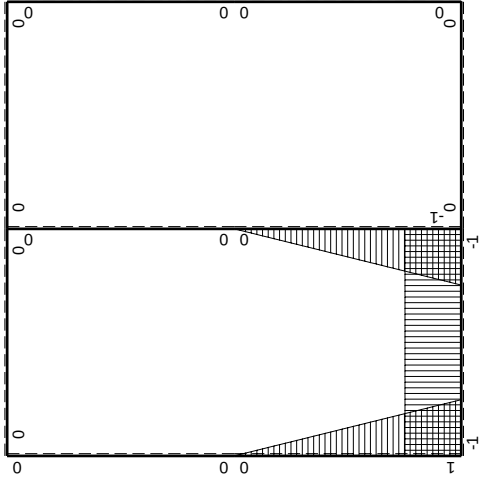
$$S = 3342. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

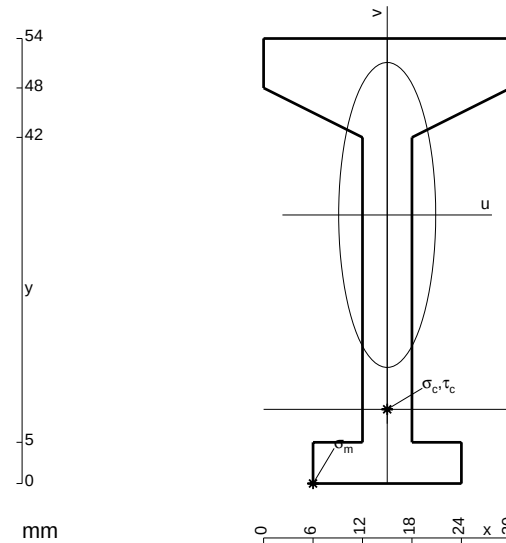
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 600. \text{ mm}^2$$

$$J_u = 205635. \text{ mm}^4$$

$$J_v = 20808. \text{ mm}^4$$

$$y_g = 32.59 \text{ mm}$$

$$T_y = 1480. \text{ N}$$

$$M_x = -1509600. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -32.59 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.2 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

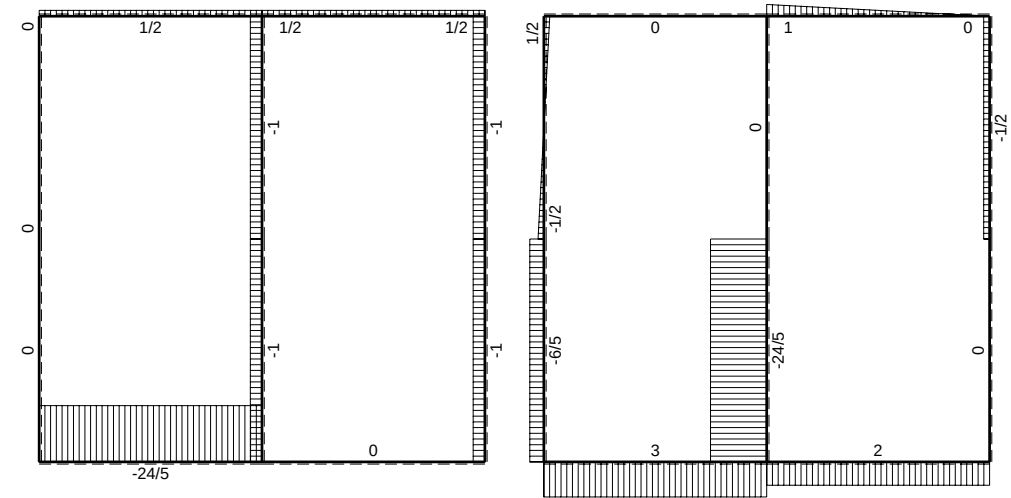
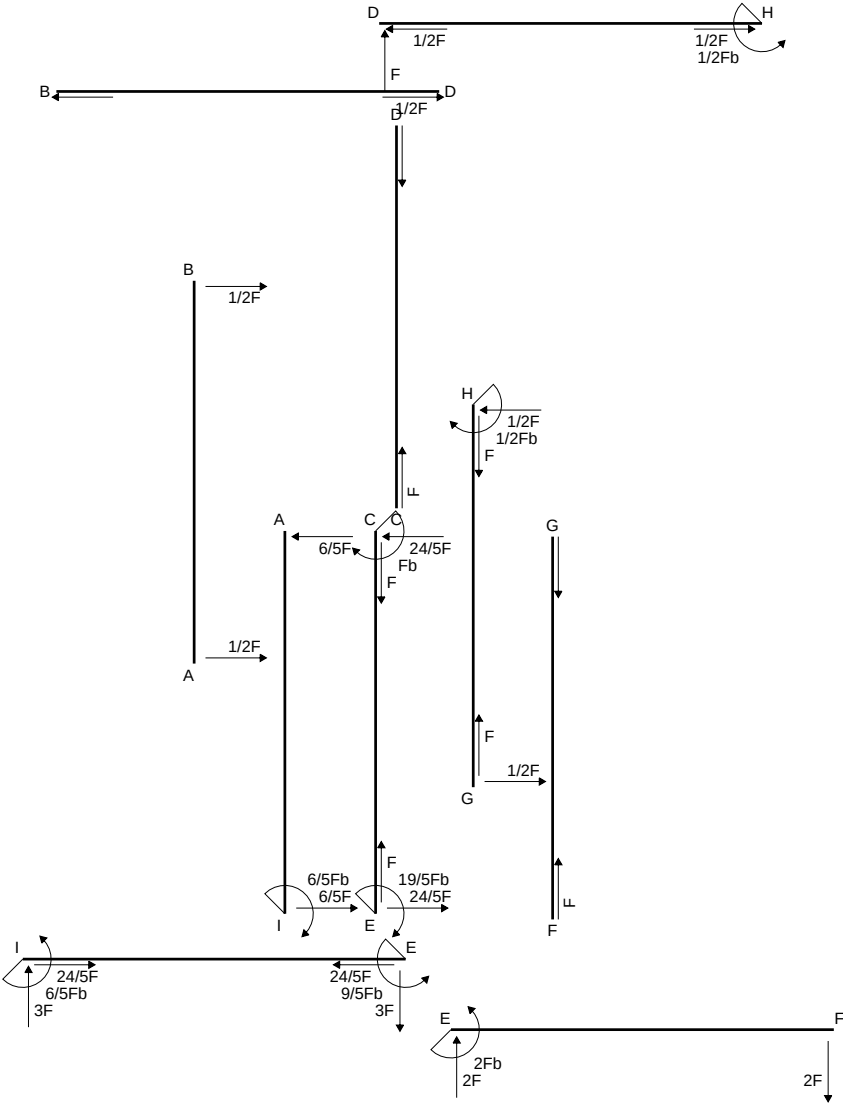
$$v_c = -23.59 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -173.2 \text{ N/mm}^2$$

$$\tau_c = 3.985 \text{ N/mm}^2$$

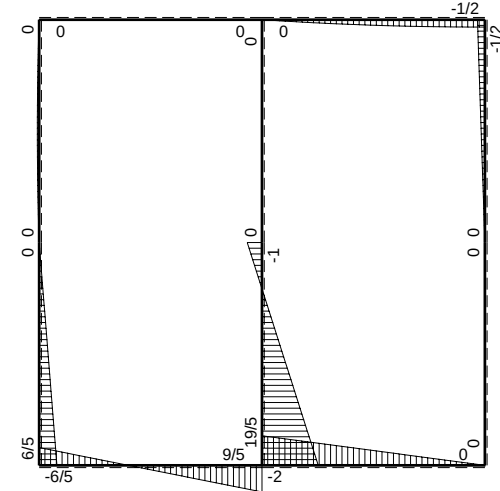
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 173.3 \text{ N/mm}^2$$

$$S = 3322. \text{ mm}^3$$

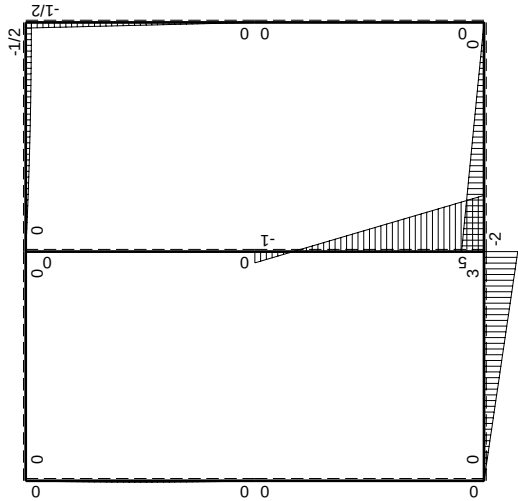
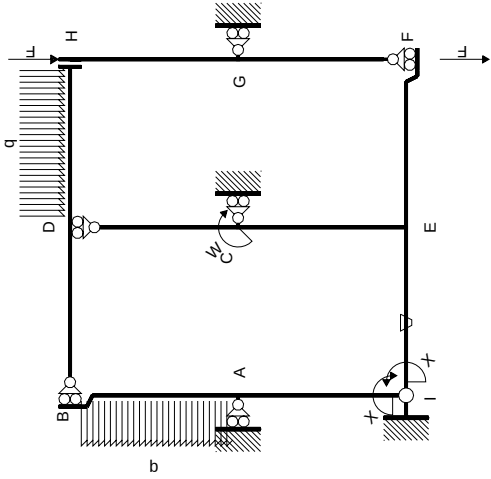


← ⊕ → F

↑ ⊕ ↓ F

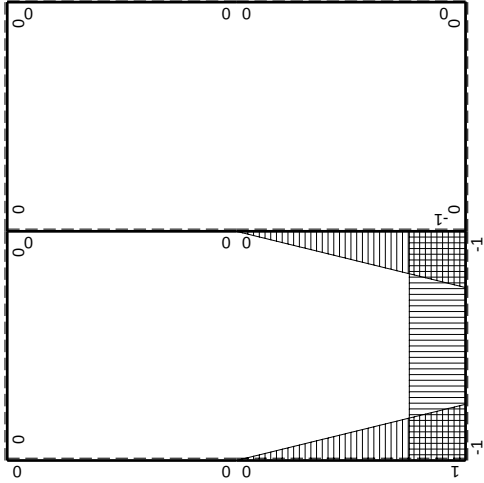


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica X=W_{IE}

→	M _x (x)	M _o (x)	θ	M _x M _o	M _x θ	M _x M _x	$\int M_x(M_o/EJ+\theta)dx$	$\int XM_xM_x/EJdx$
AB b	0	-1/2Fx+1/2qx ²	0	0	0	0	0+0	0
BA b	0	1/2Fx-1/2qx ²	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-1/2Fx	0	0	0	0	0+0	0
HG b	0	1/2Fb-1/2Fx	0	0	0	0		
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0
DH b	0	Fx-1/2qx ²	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	-1+x/b	5Fb-6Fx	0	-5Fb+11Fx-6Fx ² /b	0	1-2x/b+x ² /b ²	(-3/2+0)Fb ² /EJ	1/3Xb/EJ
CE b	x/b	Fb-6Fx	0	Fx-6Fx ² /b	0	x ² /b ²		
IA b	1-x/b	0	0	0	0	1-2x/b+x ² /b ²	0+0	1/3Xb/EJ
AI b	-x/b	0	0	0	0	x ² /b ²		
	totali						-2Fb ² /EJ	5/3Xb/EJ
	iperstatica X=W _{IE}						6/5Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

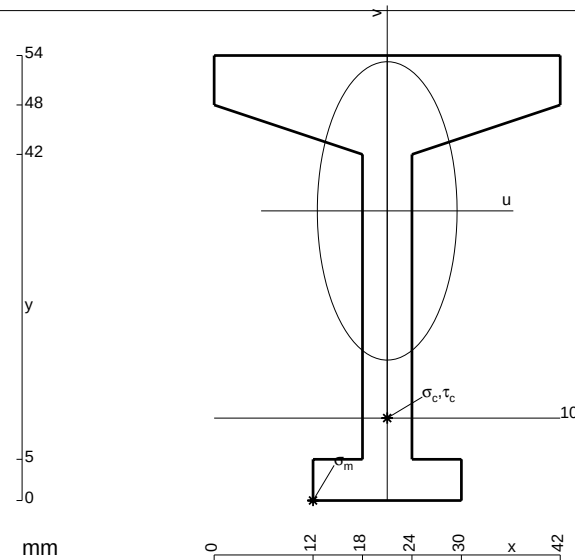
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$



$$A = 708. \text{ mm}^2$$

$$J_u = 232181. \text{ mm}^4$$

$$J_v = 50940. \text{ mm}^4$$

$$y_g = 35.14 \text{ mm}$$

$$T_y = 2440. \text{ N}$$

$$M_x = -1317600. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -35.14 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.4 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

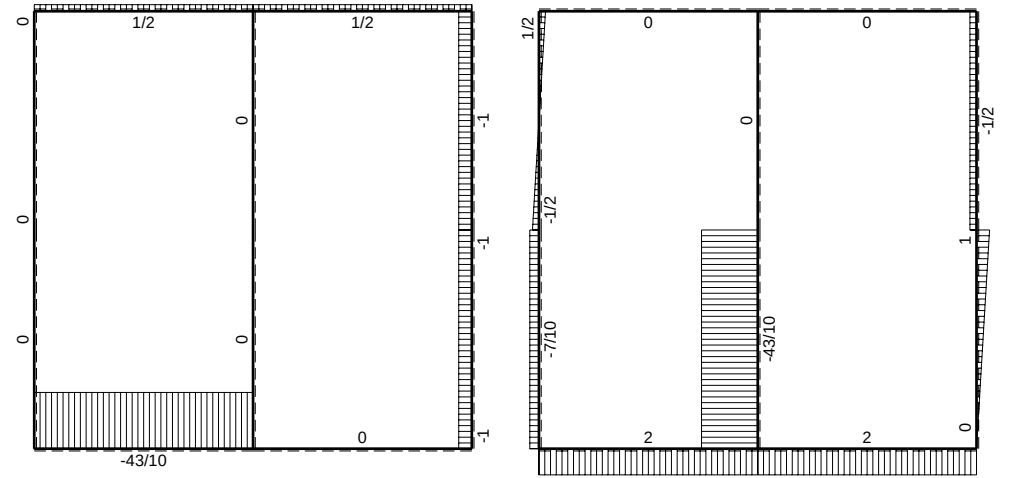
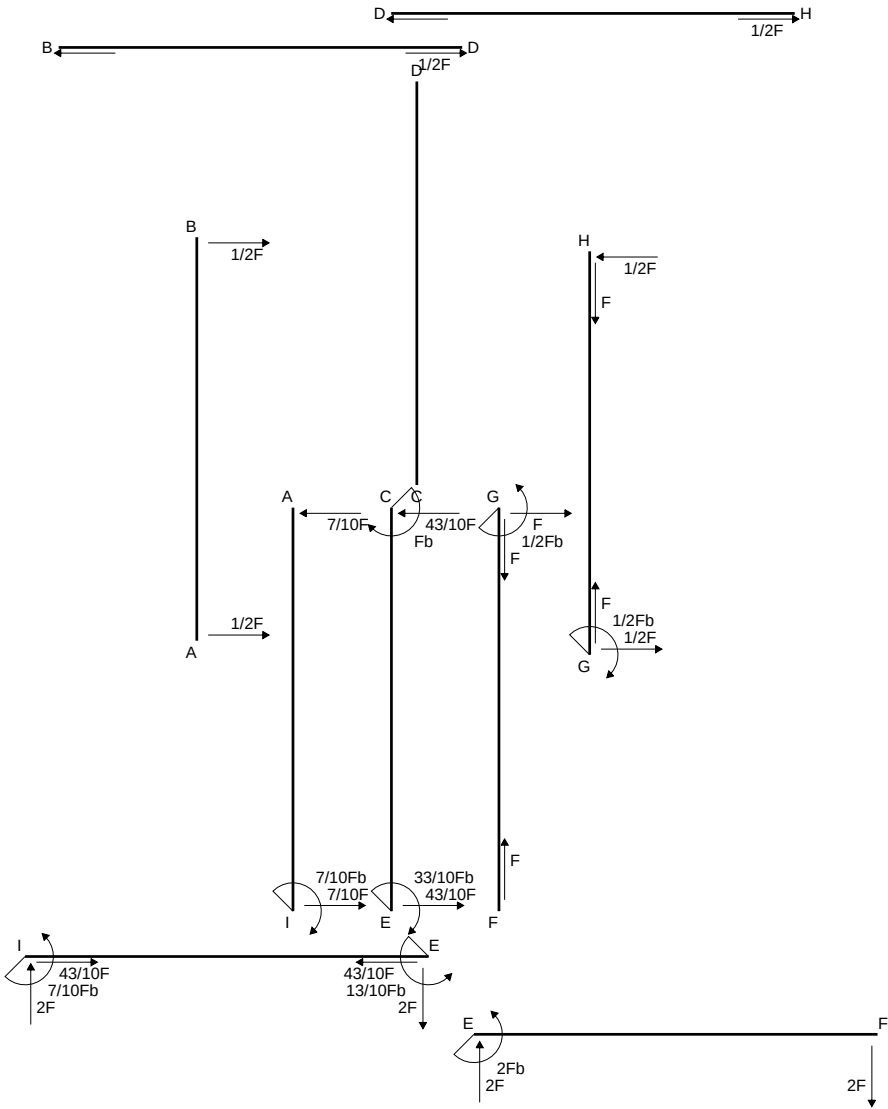
$$v_c = -25.14 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -142.7 \text{ N/mm}^2$$

$$\tau_c = 6.598 \text{ N/mm}^2$$

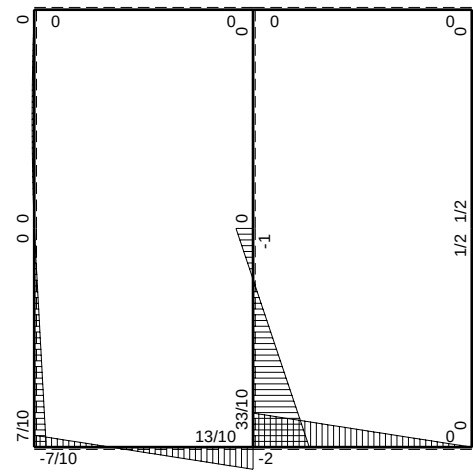
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 143.1 \text{ N/mm}^2$$

$$S = 3767. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F_b

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-5Fx$	0	$-4Fb+9Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-5Fx$	0	$Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x0} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x0} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

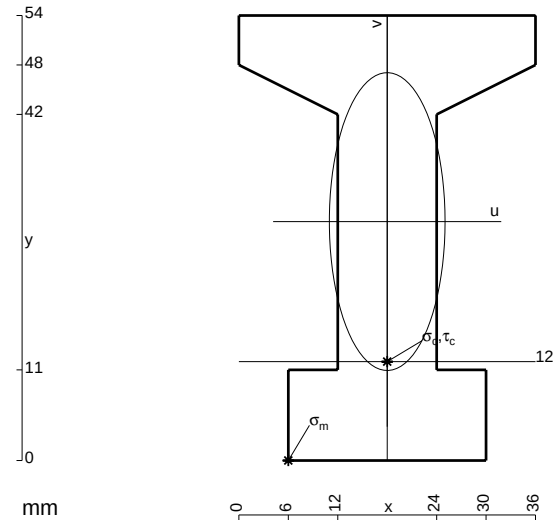
$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x0} = \int_0^b (-4 + 9x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 9/2 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 9/2 b - 5/3 b) Fb \frac{1}{EJ} = -7/6 Fb^2/EJ$$

$$L_{CE}^{x0} = \int_0^b (x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 5/3 b) Fb \frac{1}{EJ} = -7/6 Fb^2/EJ$$



$$A = 996. \text{ mm}^2$$

$$J_u = 325364. \text{ mm}^4$$

$$J_v = 49104. \text{ mm}^4$$

$$y_g = 28.99 \text{ mm}$$

$$T_y = 3980. \text{ N}$$

$$M_x = -2348200. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.99 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.3 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

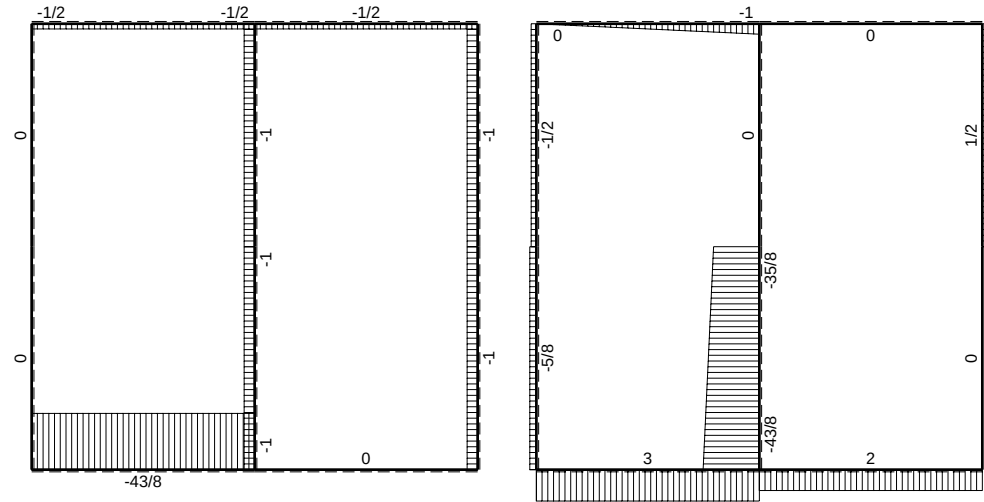
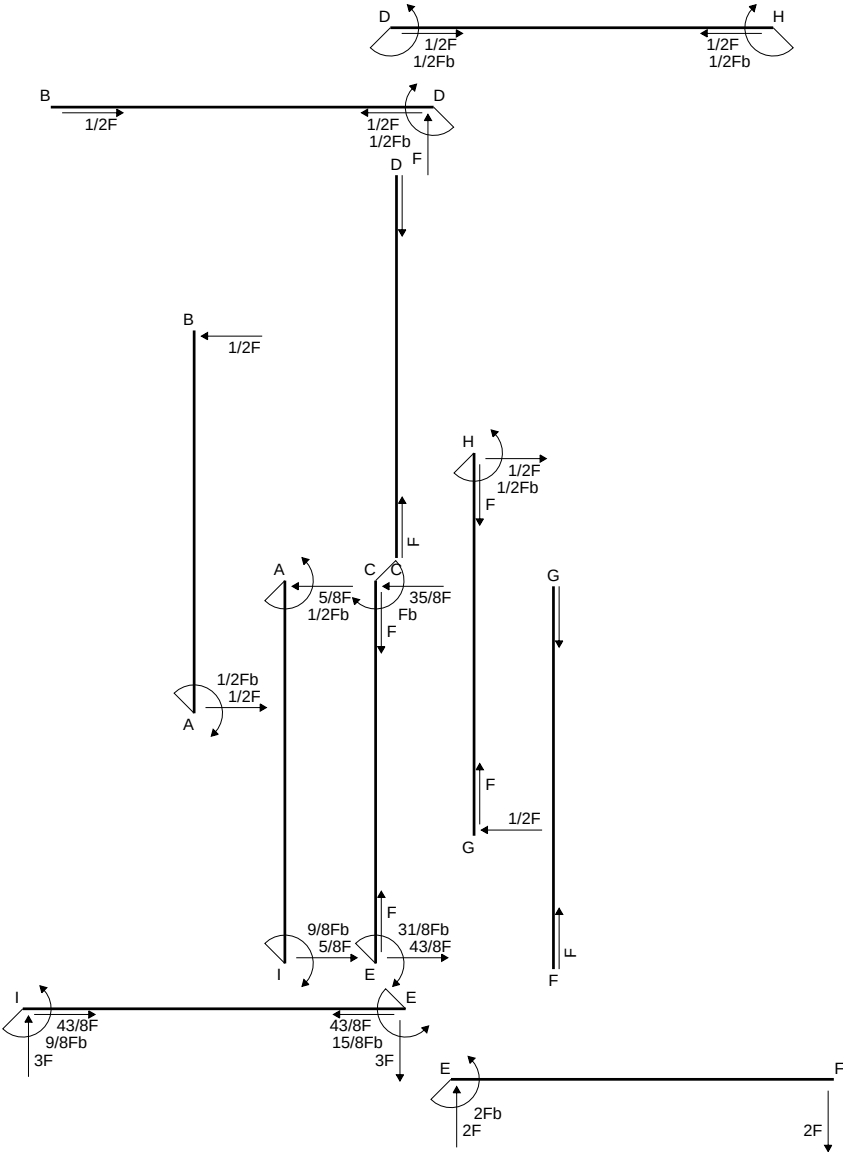
$$v_c = -16.99 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -122.6 \text{ N/mm}^2$$

$$\tau_c = 6.537 \text{ N/mm}^2$$

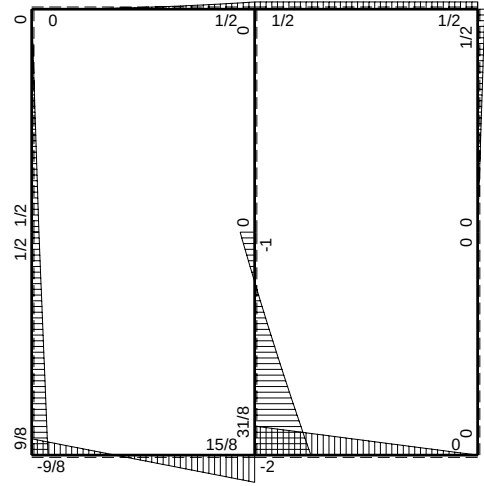
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 123.2 \text{ N/mm}^2$$

$$S = 6412. \text{ mm}^3$$



← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F



↺ $\boxed{+}$ ↻ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-13/2Fx+1/2qx^2$	0	$-5Fb+23/2Fx-7Fx^2/b+1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-35/24+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-11/2Fx-1/2qx^2$	0	$Fx-11/2Fx^2/b-1/2qx^3/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-15/8Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 23/2 x/b - 7x^2/b^2 + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx$$

$$= \left[-5x + 23/4 x^2/b - 7/3 x^3/b^2 + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 23/4 b - 7/3 b + 1/8 b) Fb \frac{1}{EJ} = -35/24 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 11/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 11/6 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

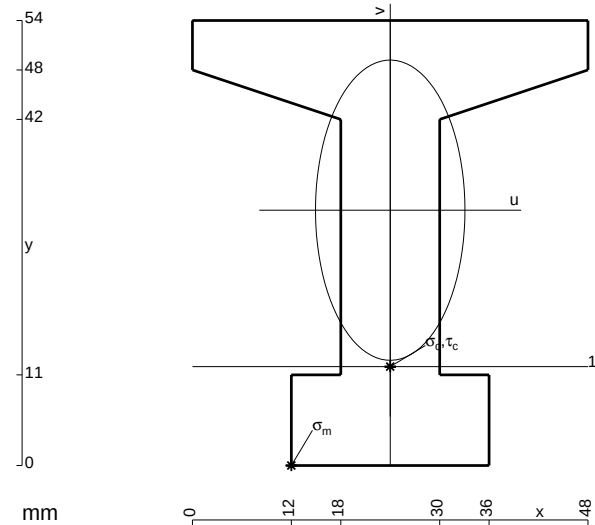
$$= (1/2 b - 11/6 b - 1/8 b) Fb \frac{1}{EJ} = -35/24 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 1104. \text{ mm}^2$$

$$J_u = 366560. \text{ mm}^4$$

$$J_v = 90792. \text{ mm}^4$$

$$y_g = 30.98 \text{ mm}$$

$$T_y = 4060. \text{ N}$$

$$M_x = -2598400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.98 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

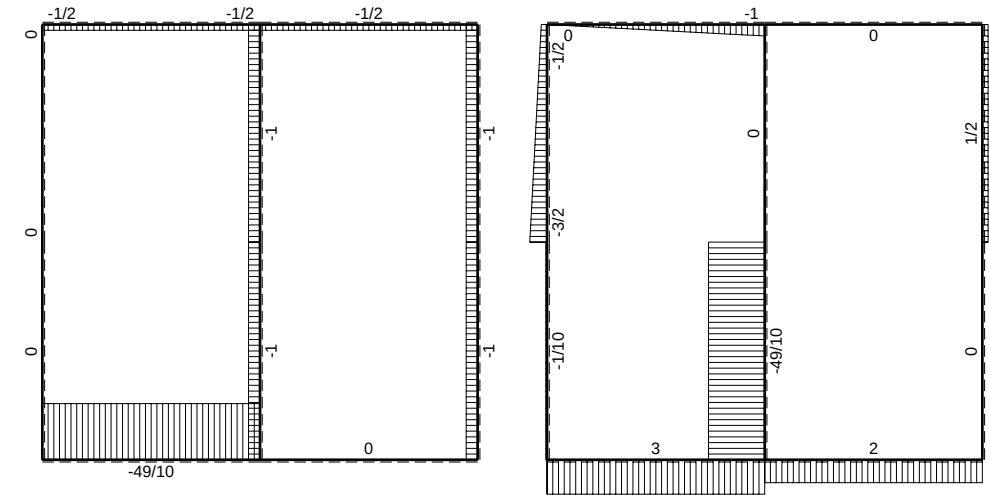
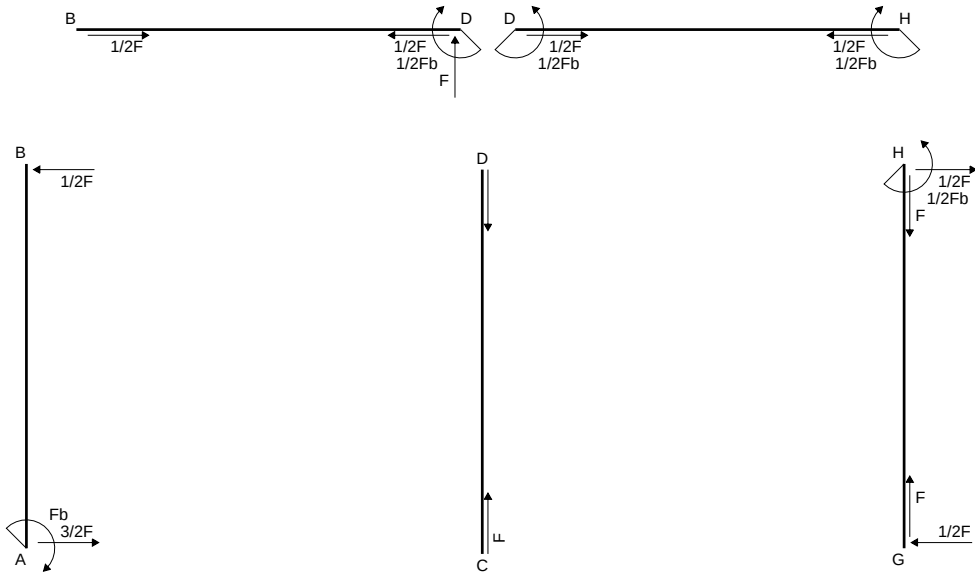
$$v_c = -18.98 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -134.6 \text{ N/mm}^2$$

$$\tau_c = 6.425 \text{ N/mm}^2$$

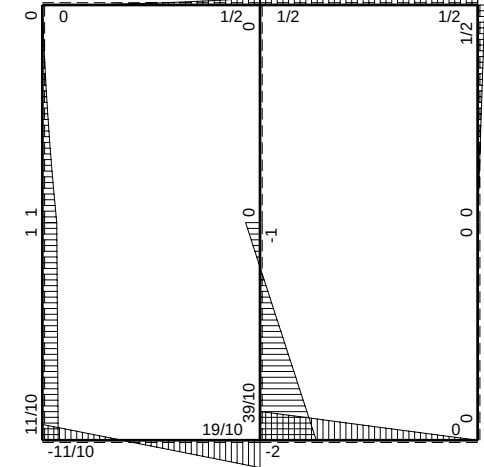
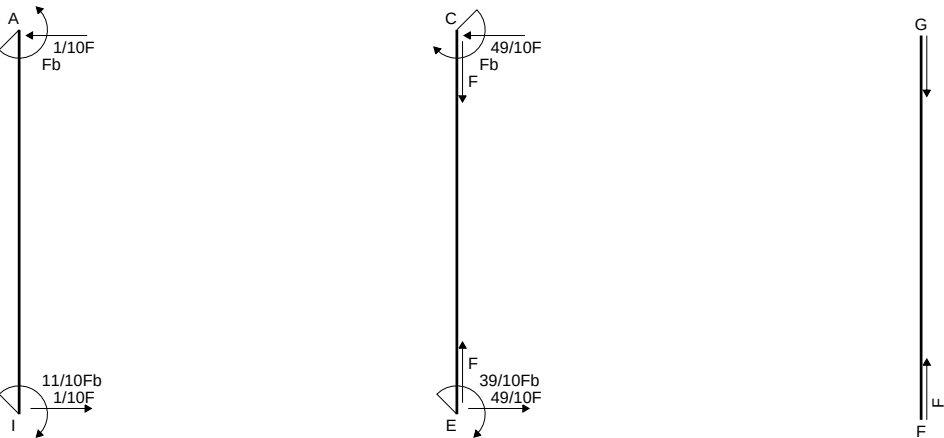
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 135. \text{ N/mm}^2$$

$$S^* = 6962. \text{ mm}^3$$

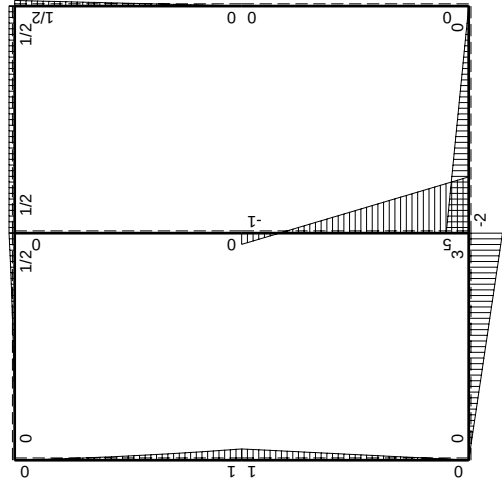
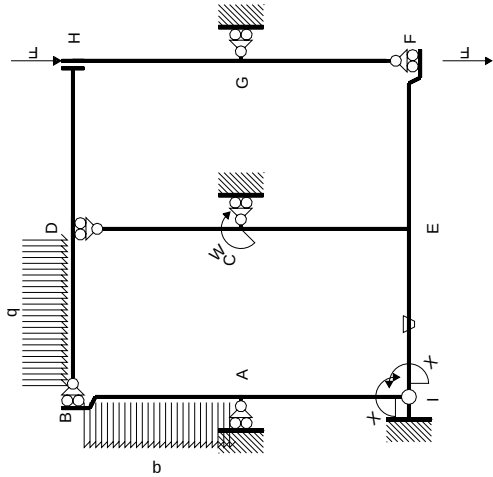


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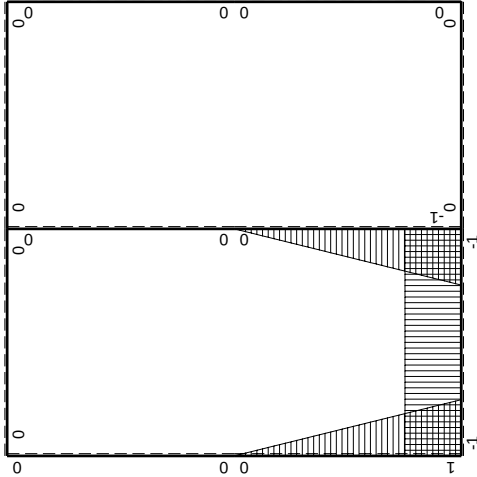


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

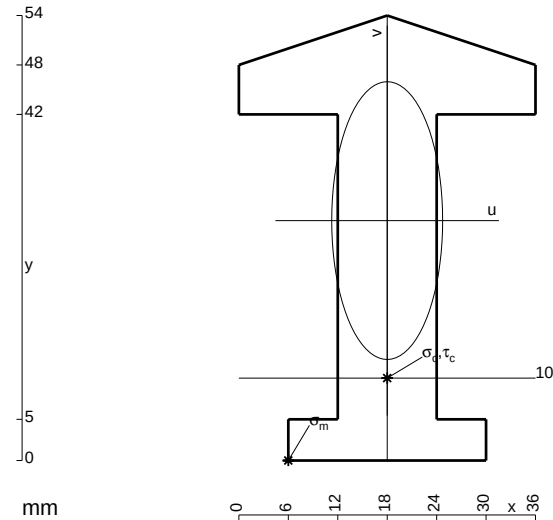
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 888. \text{ mm}^2$$

$$J_u = 252380. \text{ mm}^4$$

$$J_v = 40248. \text{ mm}^4$$

$$y_g = 29.11 \text{ mm}$$

$$T_y = 2840. \text{ N}$$

$$M_x = -1988000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.11 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.3 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

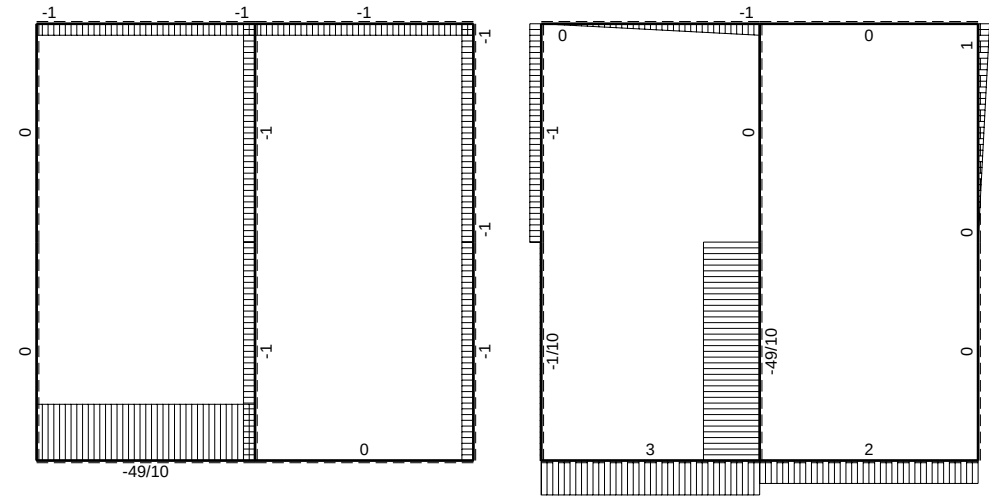
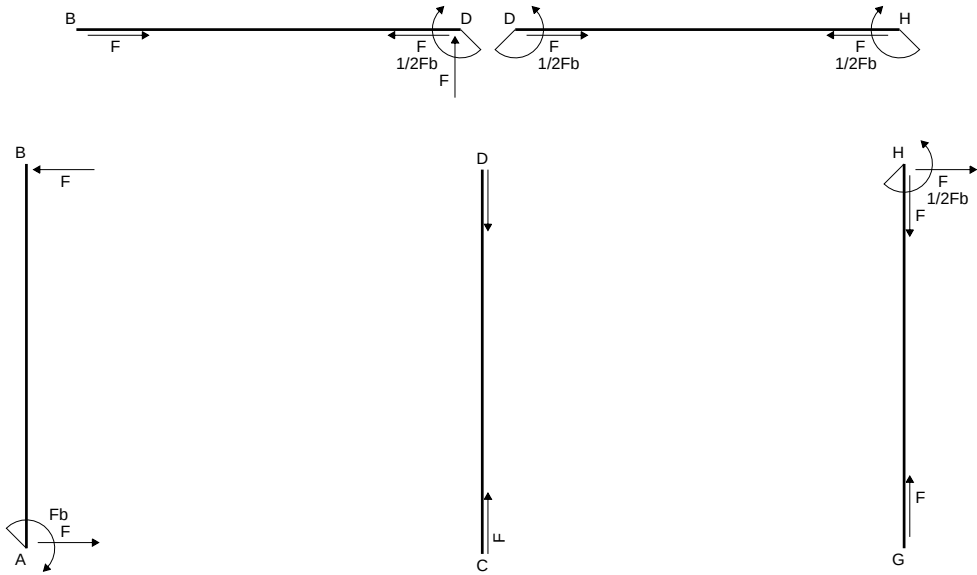
$$v_c = -19.11 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -150.6 \text{ N/mm}^2$$

$$\tau_c = 4.211 \text{ N/mm}^2$$

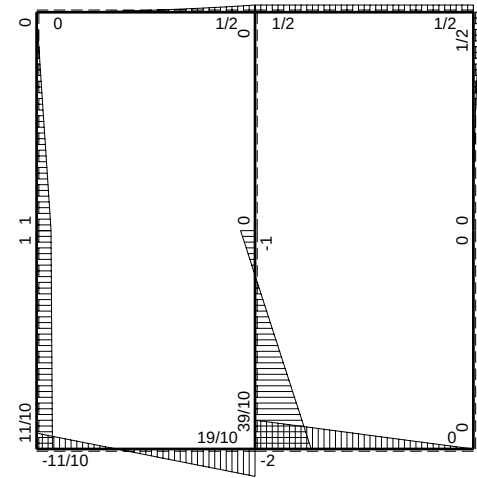
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 150.7 \text{ N/mm}^2$$

$$S = 4491. \text{ mm}^3$$

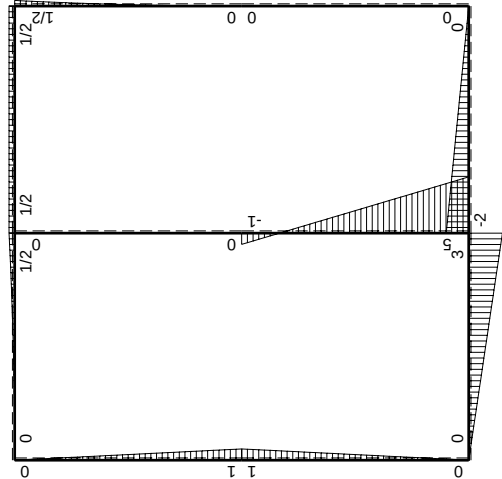
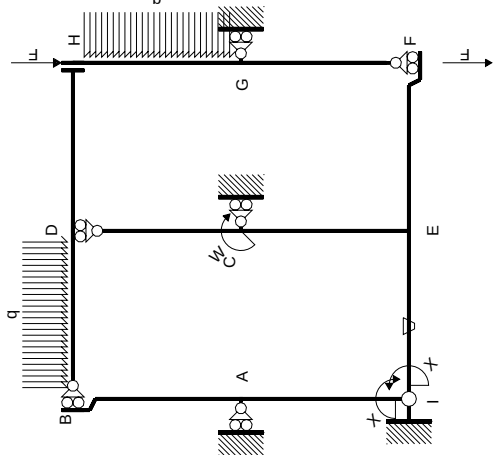


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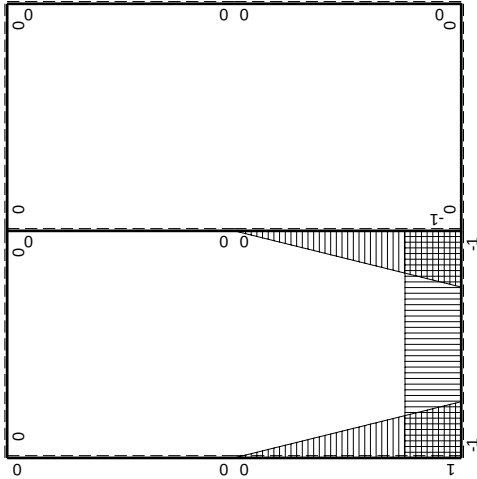


⊕ ⊖ Fb



Schema di calcolo iperstatico

M₀ flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-Fx$	0	0	0	0	0+0	0
BA b	0	$-Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

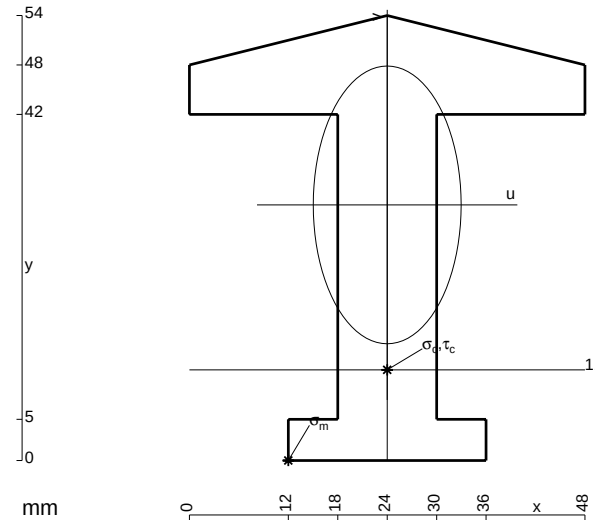
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

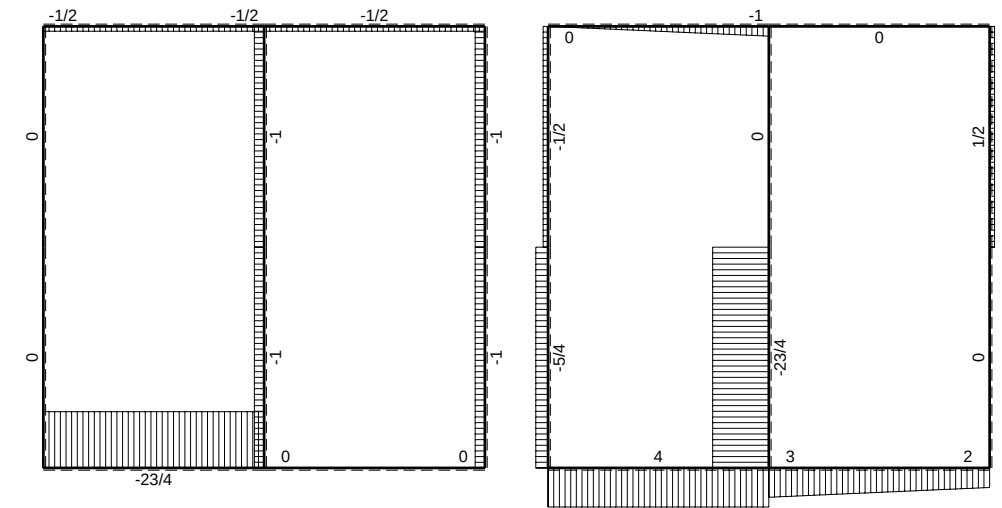
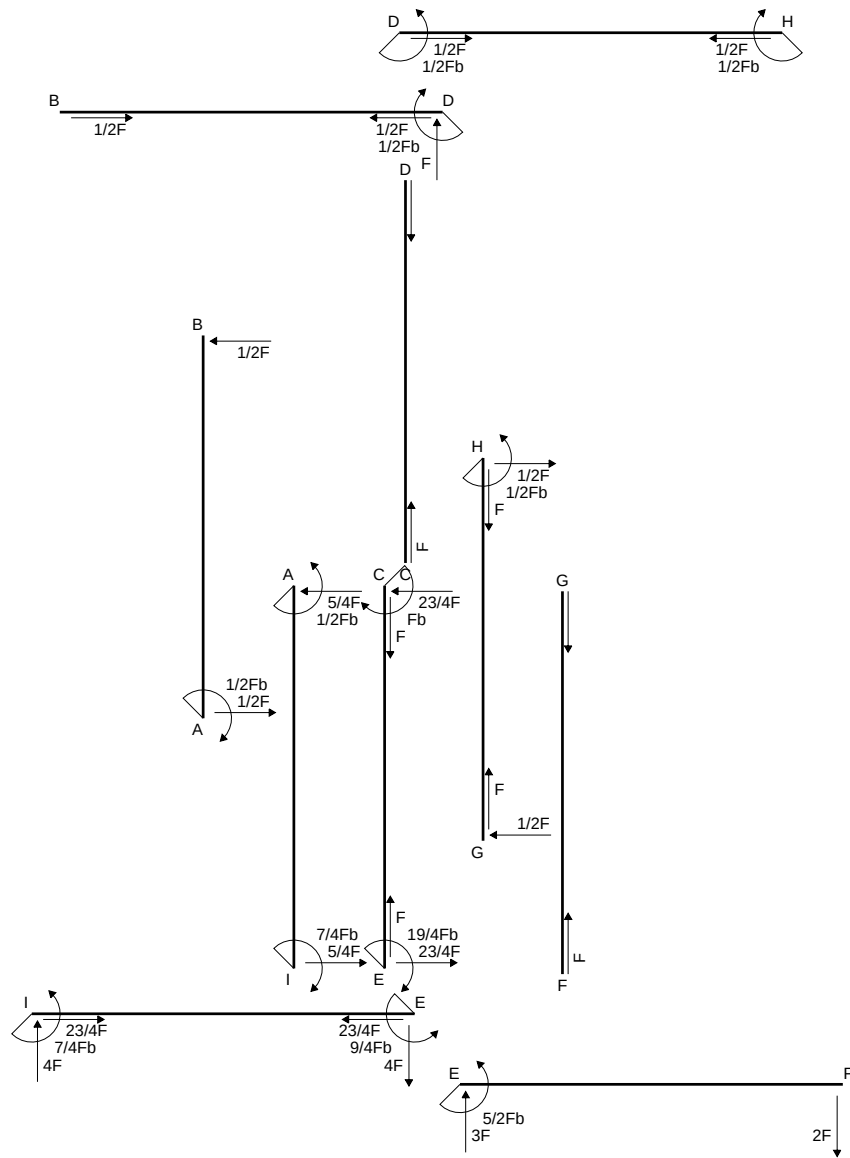
$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

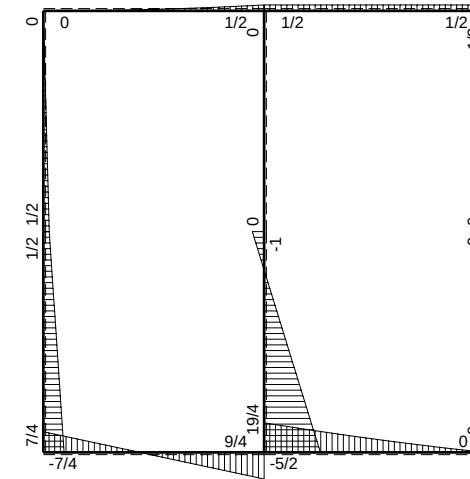
$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

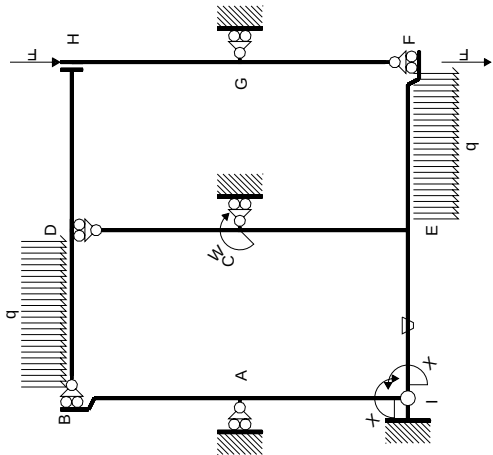


$$\begin{aligned} A &= 996. \text{ mm}^2 \\ J_u &= 282932. \text{ mm}^4 \\ J_v &= 80208. \text{ mm}^4 \\ y_g &= 31.02 \text{ mm} \\ T_y &= 2900. \text{ N} \\ M_x &= -2175000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.02 \text{ mm} \\ \sigma_m &= -Mv/J_u = -238.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 11. \text{ mm} \\ v_c &= -20.02 \text{ mm} \\ \sigma_c &= -Mv/J_u = -153.9 \text{ N/mm}^2 \\ \tau_c &= 4.339 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 154.1 \text{ N/mm}^2 \\ S &= 5079. \text{ mm}^3 \end{aligned}$$

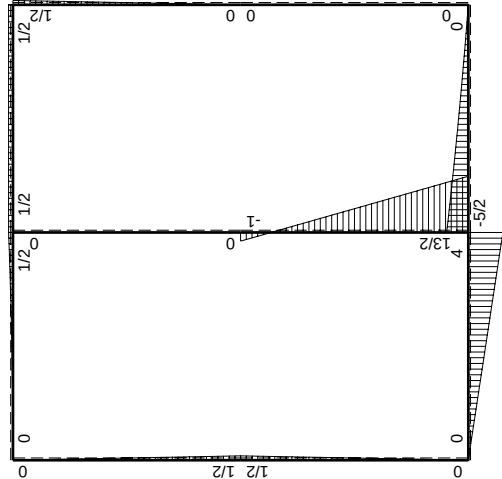


A diagram showing a positive charge, represented by a square box with a '+' sign inside. A horizontal arrow points to the left from the charge, and another horizontal arrow points to the right from the charge, labeled with the letter 'F'.

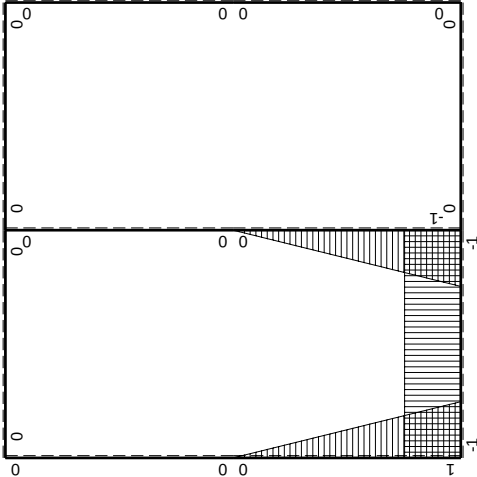




Schema di calcolo iperstatico



M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2 Fb - 1/2 Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2 Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2 Fb + 3Fx - 1/2 qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx + 1/2 qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2 Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2 Fb + 1/2 Fx$	0	0	0	0		
HD b	0	$1/2 Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2 Fb$	0	0	0	0		
DB b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2 qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2 Fb - 15/2 Fx$	0	$-13/2 Fb + 14Fx - 15/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3 Xb/EJ$
CE b	x/b	$Fb - 15/2 Fx$	0	$Fx - 15/2 Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2 Fx$	0	$1/2 Fx - 1/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3 Xb/EJ$
AI b	$-x/b$	$-1/2 Fb + 1/2 Fx$	0	$1/2 Fx - 1/2 Fx^2/b$	0	x^2/b^2		
	totali						$-35/12 Fb^2/EJ$	$5/3 Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4 Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 14x/b - 15/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 7x^2/b - 5/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 7b - 5/2 b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 15/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 5/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

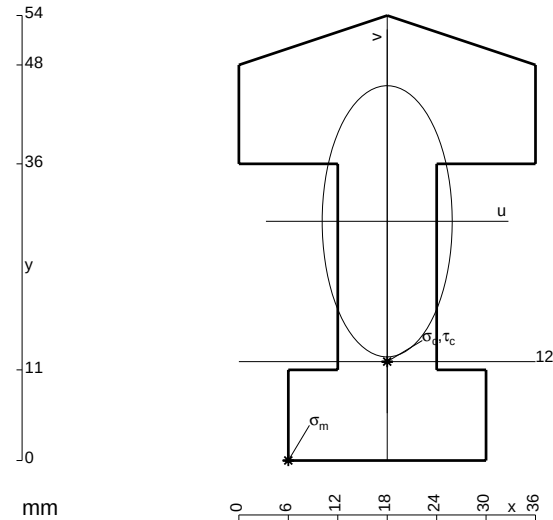
$$= (1/2 b - 5/2 b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 1104. \text{ mm}^2$$

$$J_u = 299191. \text{ mm}^4$$

$$J_v = 68760. \text{ mm}^4$$

$$y_g = 29.03 \text{ mm}$$

$$T_y = 3030. \text{ N}$$

$$M_x = -2045250. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.03 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -198.4 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

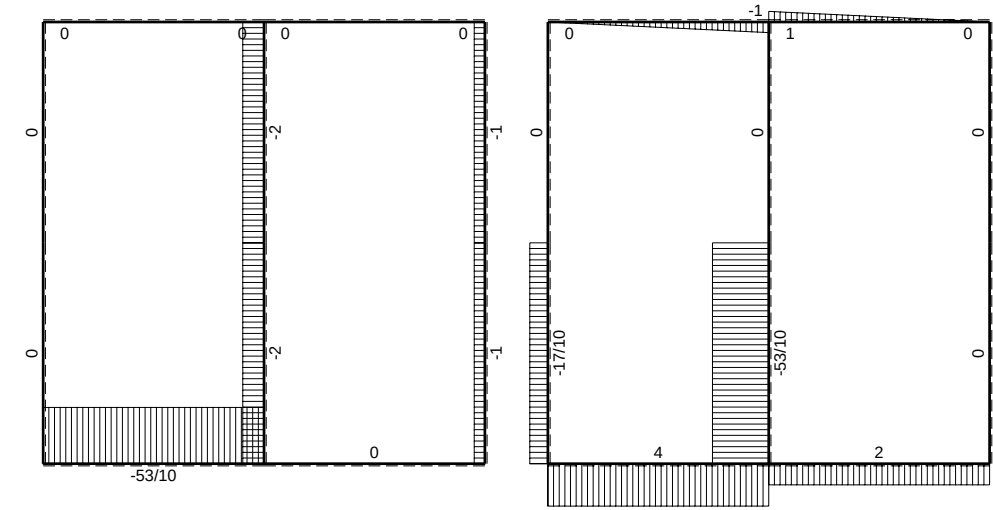
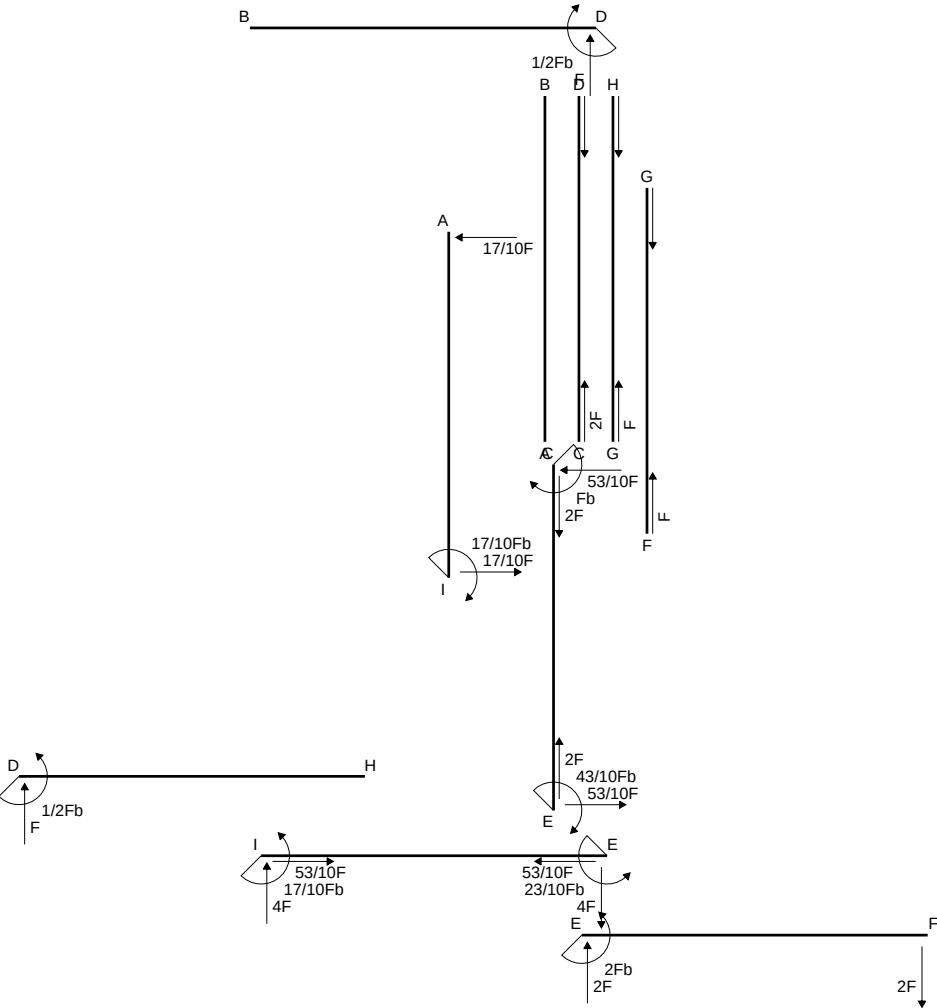
$$v_c = -17.03 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -116.4 \text{ N/mm}^2$$

$$\tau_c = 5.419 \text{ N/mm}^2$$

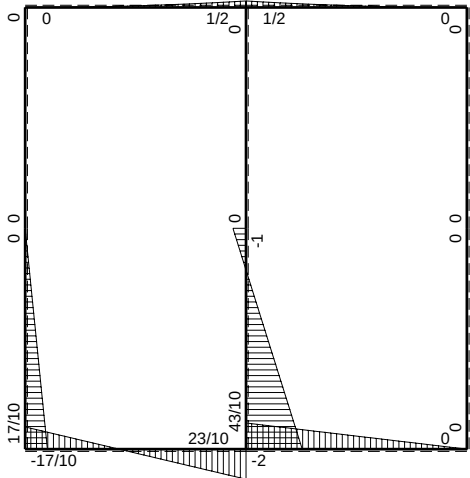
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 116.8 \text{ N/mm}^2$$

$$S = 6422. \text{ mm}^3$$

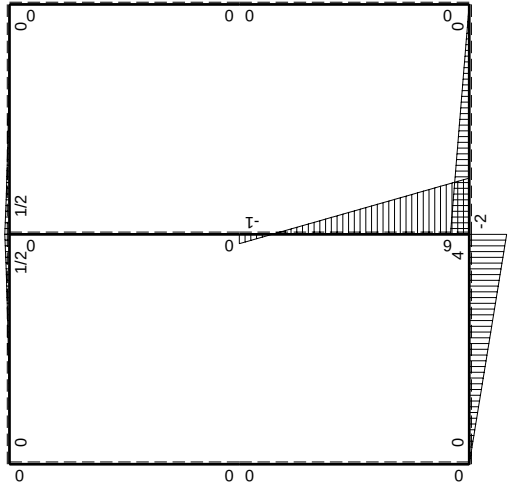
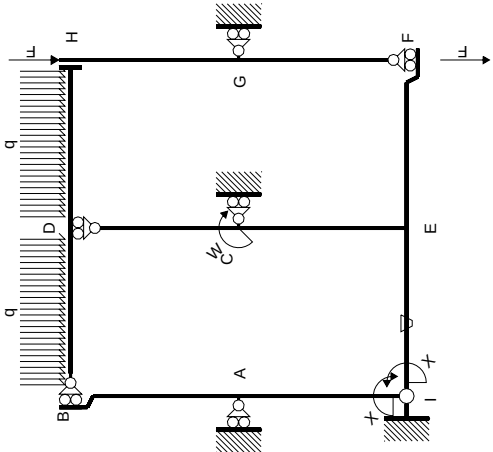


← $\boxed{+}$ → F

↑ $\boxed{+}$ ↓ F

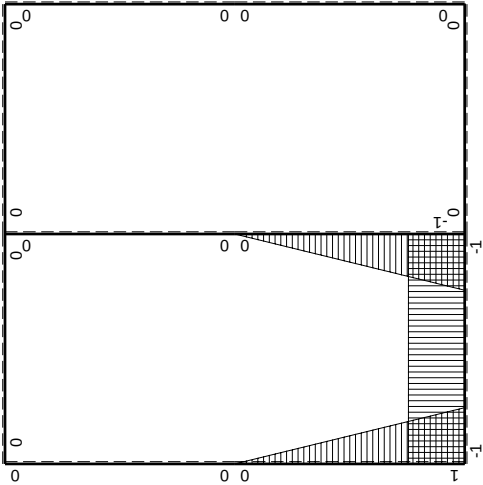


↺ $\boxed{+}$ ↻ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-7Fx$	0	$-6Fb+13Fx-7Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-7Fx$	0	$Fx-7Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-17/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$17/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

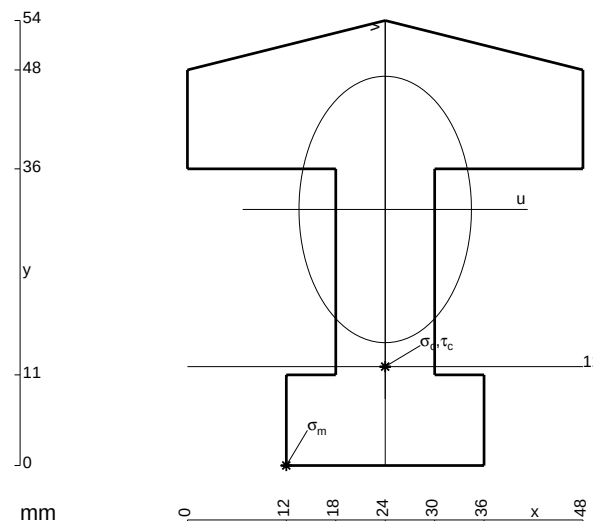
$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 13x/b - 7x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 13/2 x^2/b - 7/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

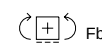
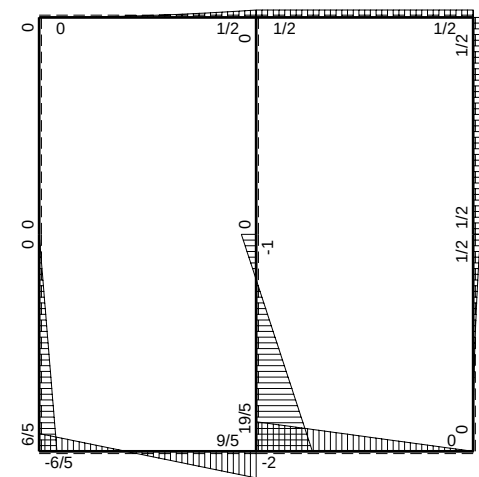
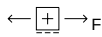
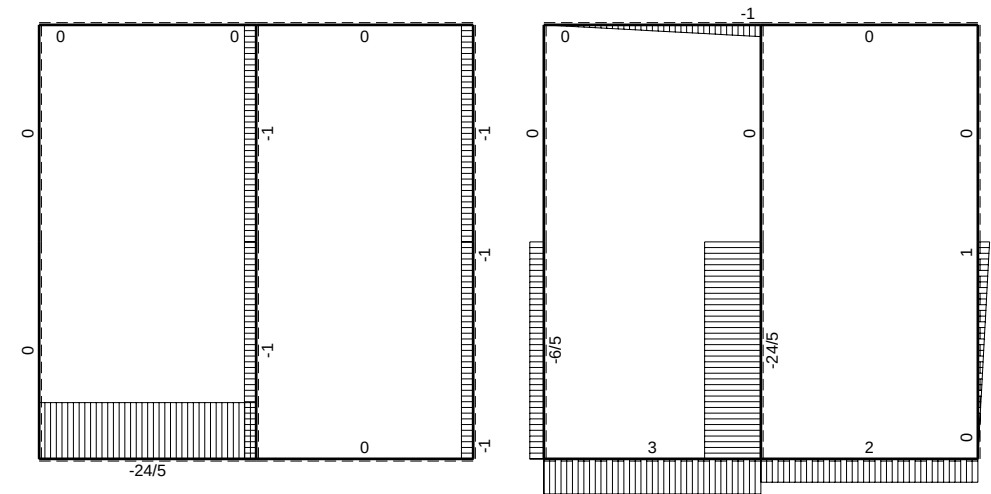
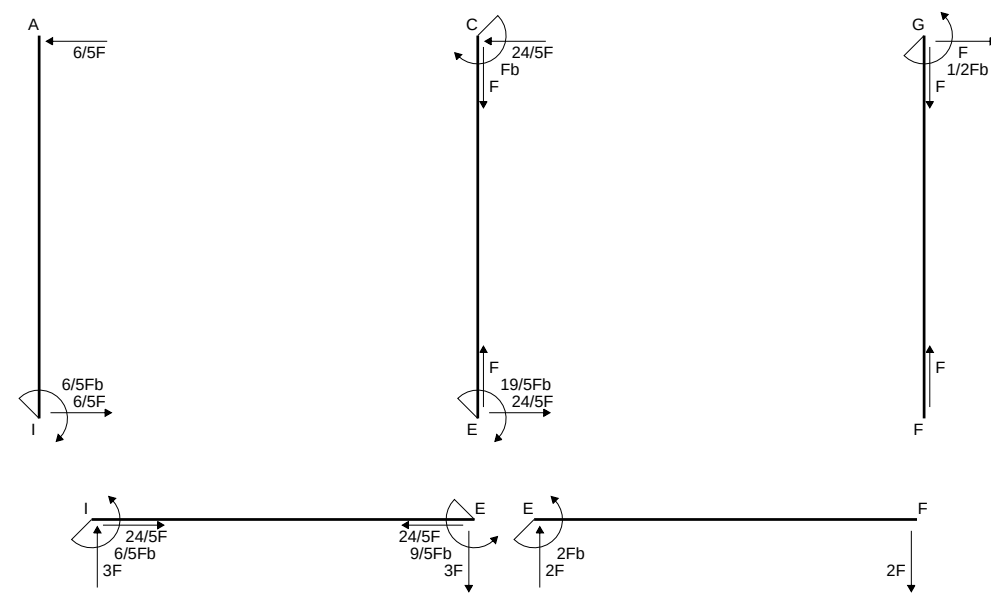
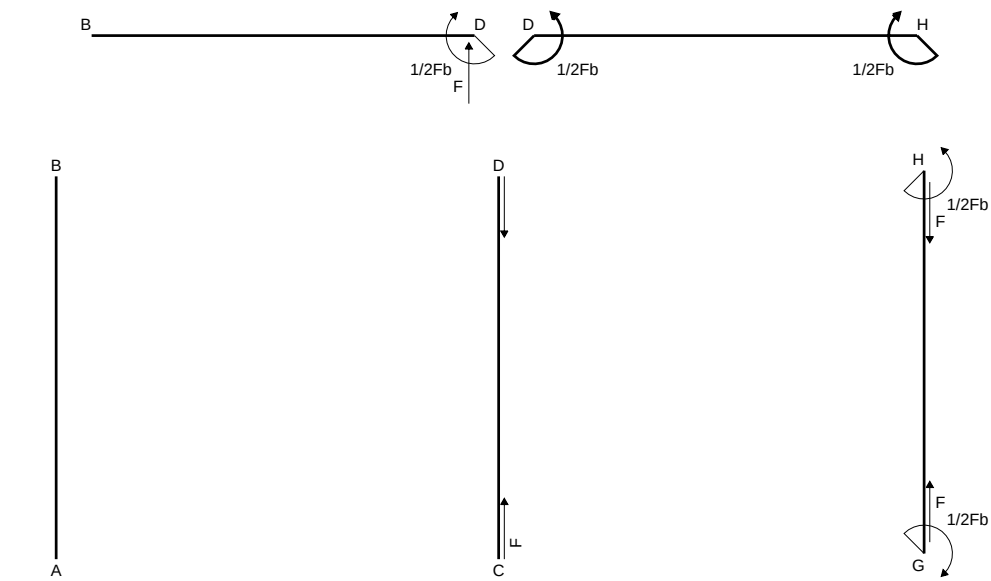
$$= (-6b + 13/2 b - 7/3 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

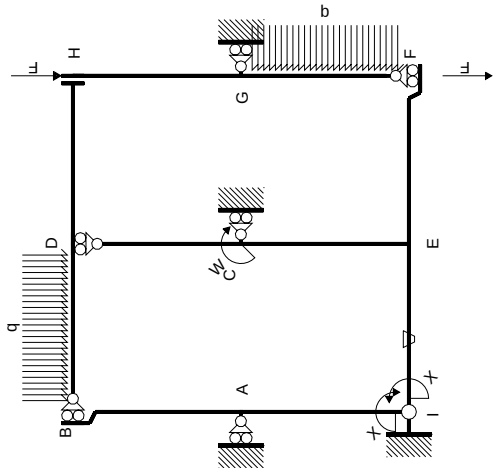
$$L_{CE}^{xo} = \int_0^b (x/b - 7x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 7/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 7/3 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$



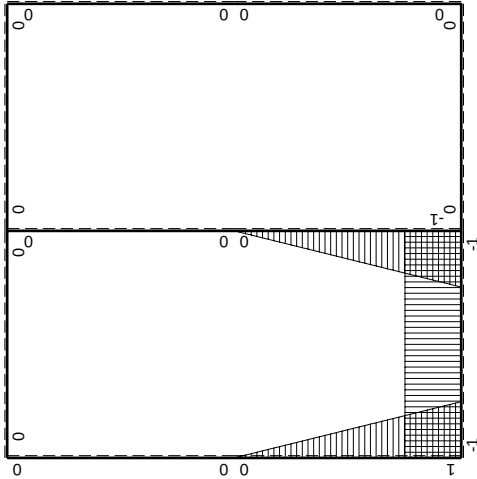
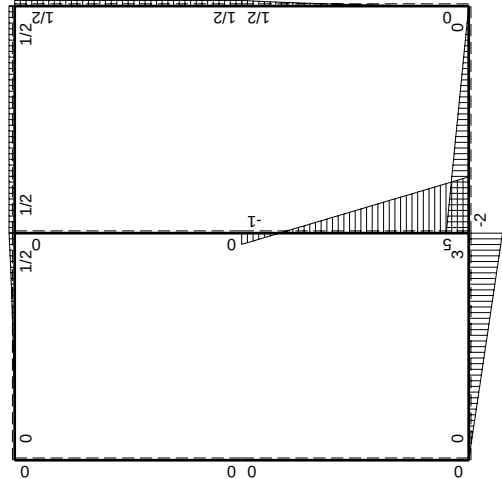
$$\begin{aligned} A &= 1284. \text{ mm}^2 \\ J_u &= 335702. \text{ mm}^4 \\ J_v &= 140688. \text{ mm}^4 \\ y_g &= 31.07 \text{ mm} \\ T_y &= 2620. \text{ N} \\ M_x &= -2253200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.07 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.5 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -19.07 \text{ mm} \\ \sigma_c &= -Mv/J_u = -128. \text{ N/mm}^2 \\ \tau_c &= 4.543 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 128.2 \text{ N/mm}^2 \\ S &= 6985. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

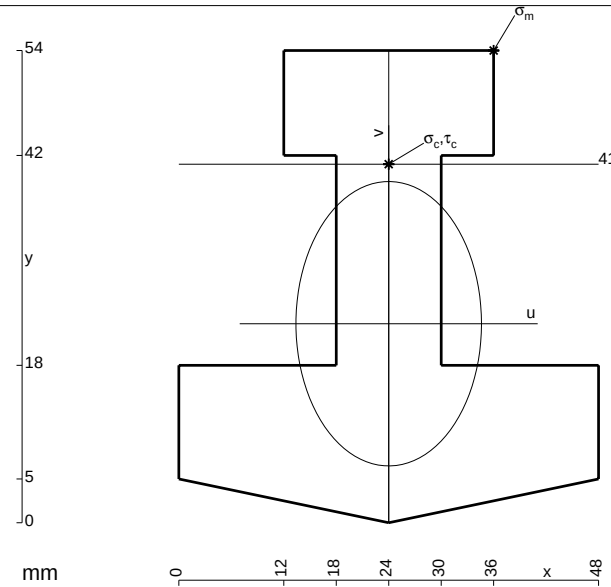
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$



$$A = 1320. \text{ mm}^2$$

$$J_u = 349206. \text{ mm}^4$$

$$J_v = 148608. \text{ mm}^4$$

$$y_g = 22.76 \text{ mm}$$

$$T_y = 2700. \text{ N}$$

$$M_x = -2457000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 31.24 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

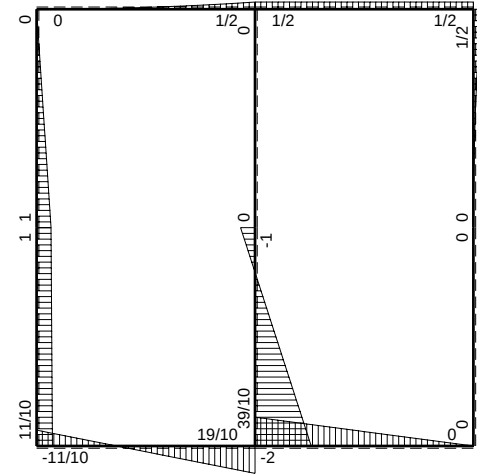
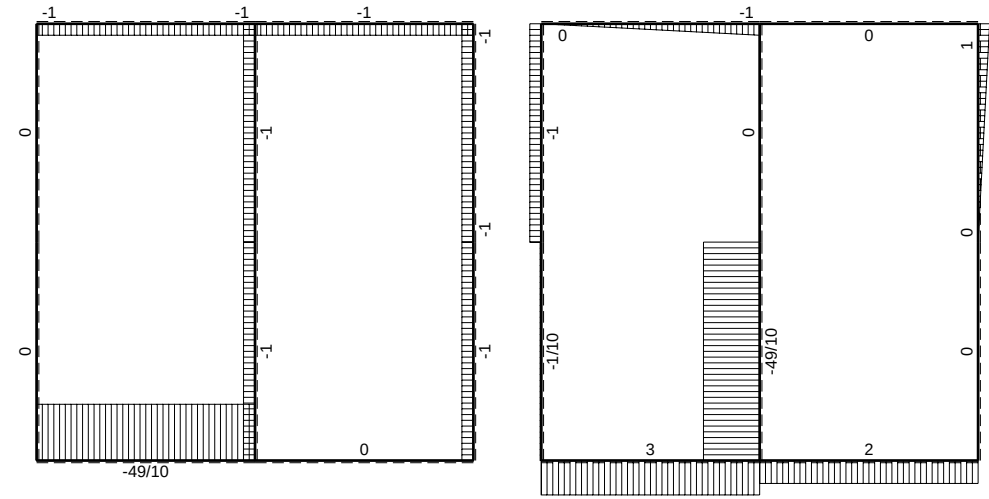
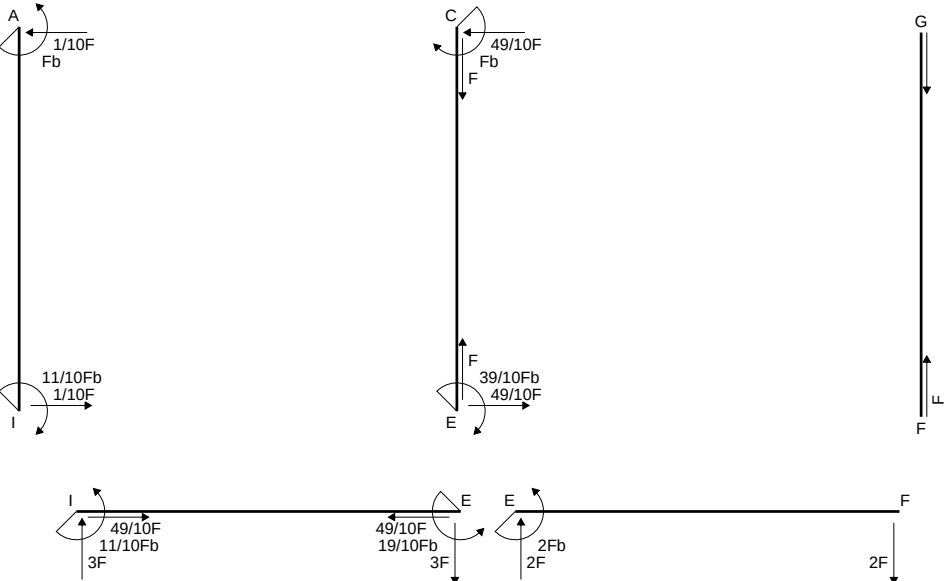
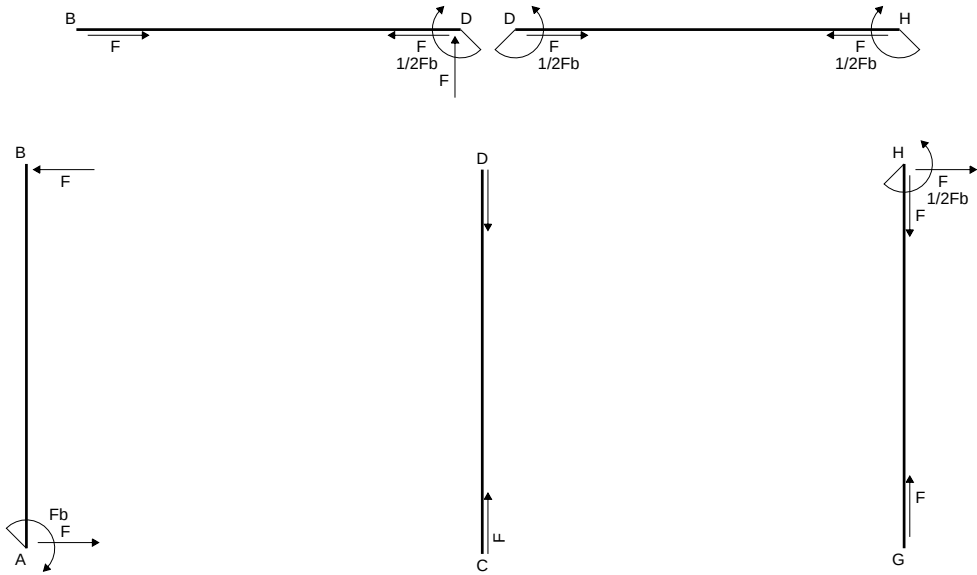
$$v_c = 18.24 \text{ mm}$$

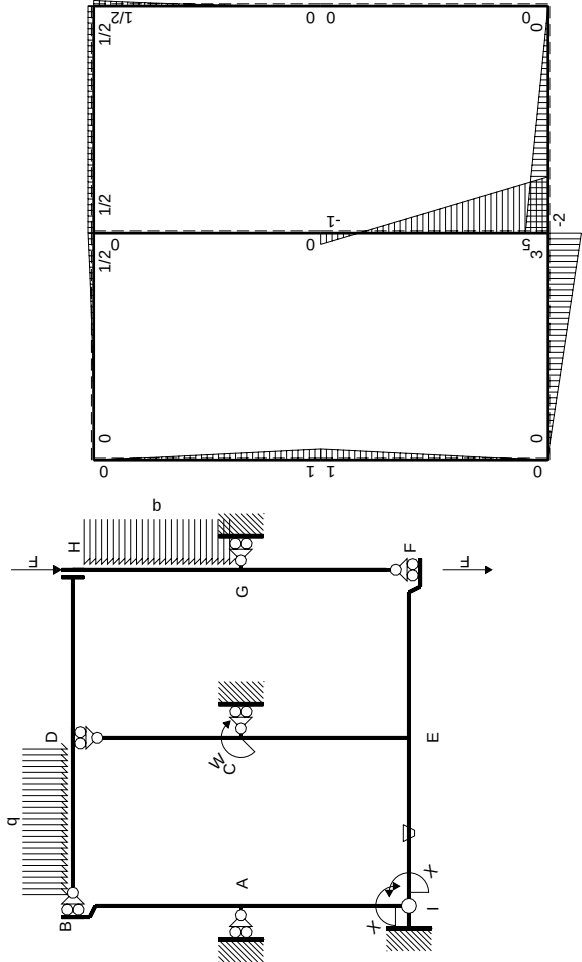
$$\sigma_c = -Mv/J_u = 128.4 \text{ N/mm}^2$$

$$\tau_c = 4.829 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 128.6 \text{ N/mm}^2$$

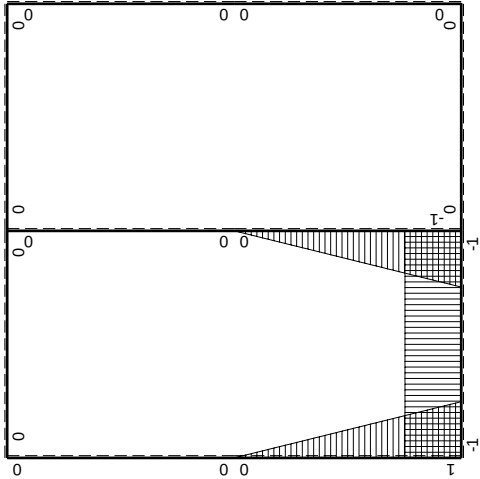
$$S = 7495. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-Fx$	0	0	0	0	0+0	0
BA b	0	$-Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	Fx	0	$Fx-Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-Fb+Fx$	0	$Fx-Fx^2/b$	0	x^2/b^2		
	totali						$-11/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

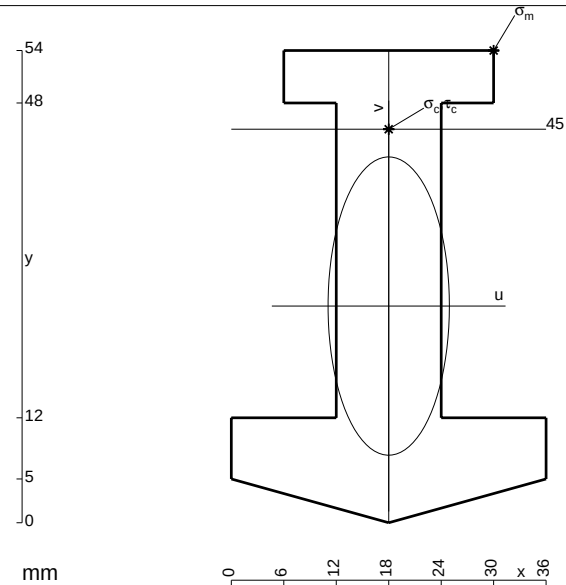
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (x/b - x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 1/3 b) Fb \frac{1}{EJ} = 1/6 Fb^2/EJ$$



$$A = 918. \text{ mm}^2$$

$$J_u = 267198. \text{ mm}^4$$

$$J_v = 44172. \text{ mm}^4$$

$$y_g = 24.78 \text{ mm}$$

$$T_y = 2160. \text{ N}$$

$$M_x = -2095200. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 29.22 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.1 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 45. \text{ mm}$$

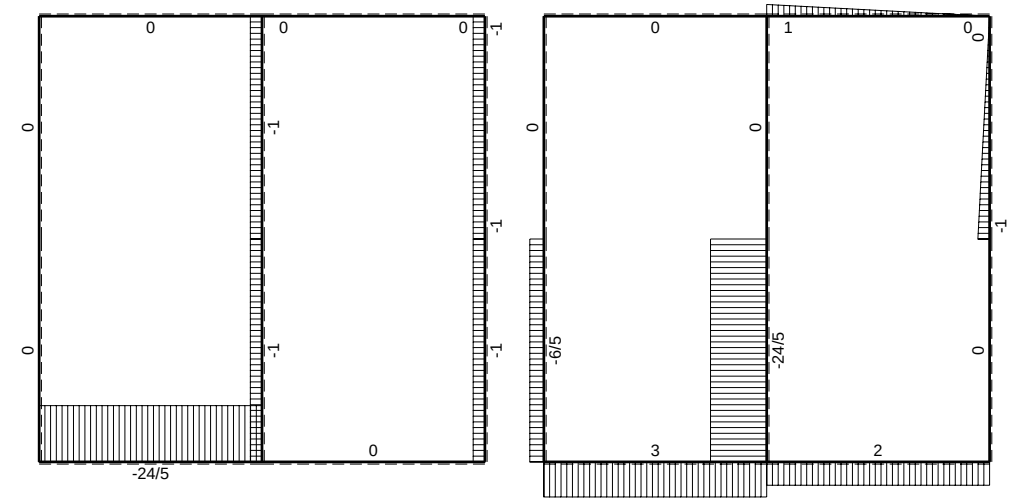
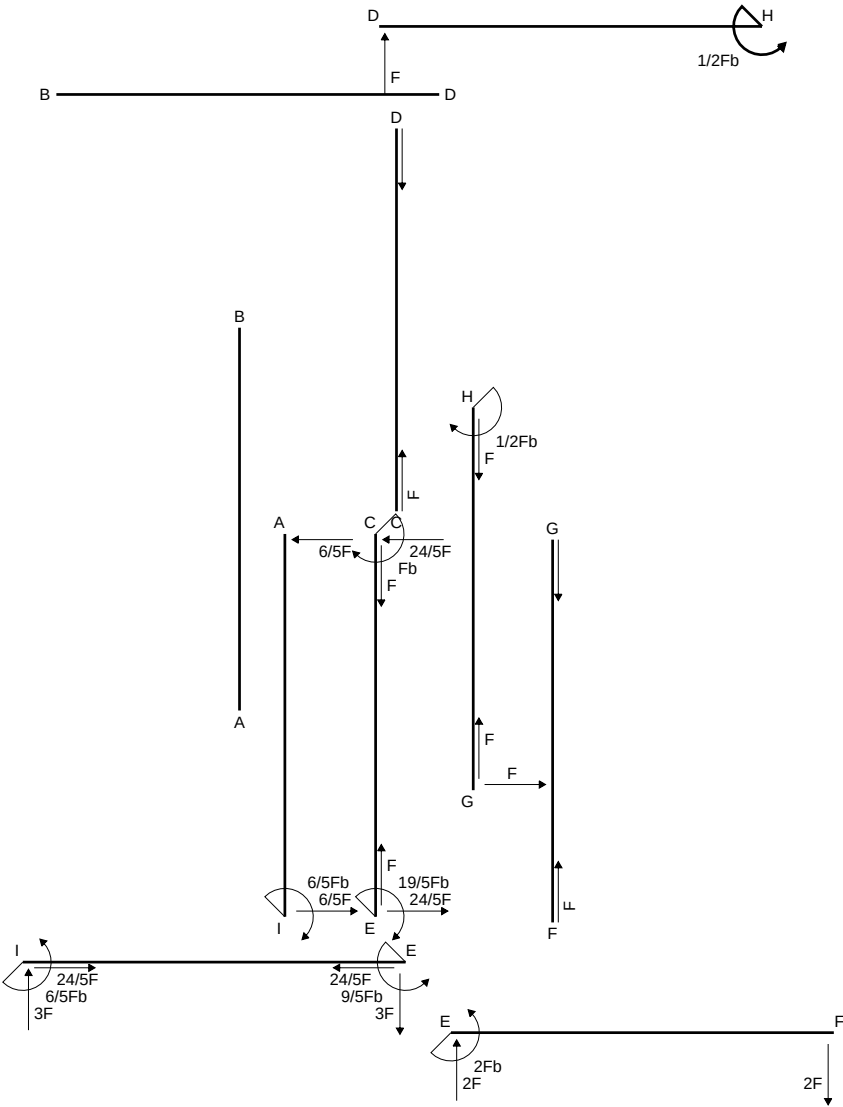
$$v_c = 20.22 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 158.6 \text{ N/mm}^2$$

$$\tau_c = 3.071 \text{ N/mm}^2$$

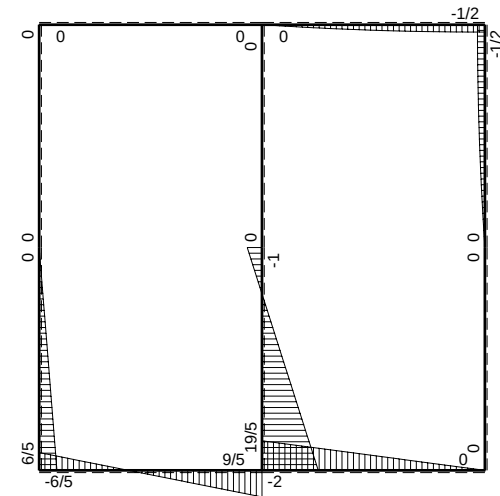
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 158.7 \text{ N/mm}^2$$

$$S = 4558. \text{ mm}^3$$

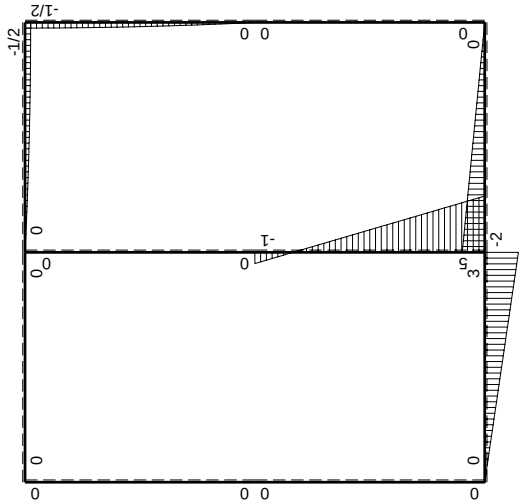
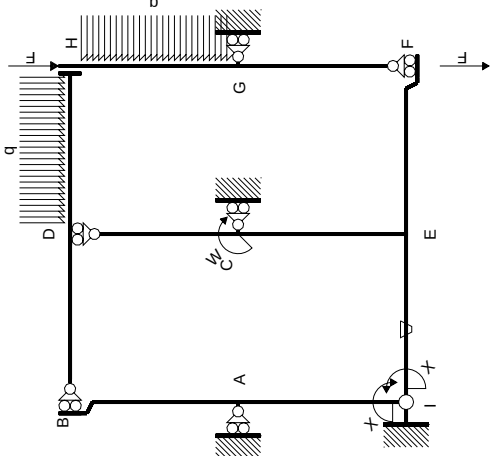


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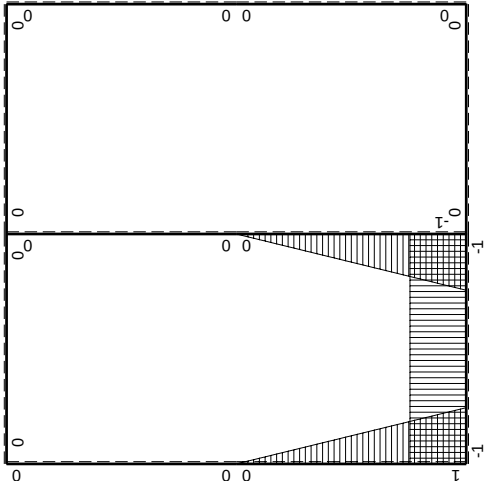


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-Fx+1/2qx ²	0	0	0	0	0+0	0
HG b	0	1/2Fb-1/2qx ²	0	0	0	0		
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0
DH b	0	Fx-1/2qx ²	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	-1+x/b	5Fb-6Fx	0	-5Fb+11Fx-6Fx ² /b	0	1-2x/b+x ² /b ²	(-3/2+0)Fb ² /EJ	1/3Xb/EJ
CE b	x/b	Fb-6Fx	0	Fx-6Fx ² /b	0	x ² /b ²		
IA b	1-x/b	0	0	0	0	1-2x/b+x ² /b ²	0+0	1/3Xb/EJ
AI b	-x/b	0	0	0	0	x ² /b ²		
	totali						-2Fb ² /EJ	5/3Xb/EJ
	iperstatica $X=W_{IE}$						6/5Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

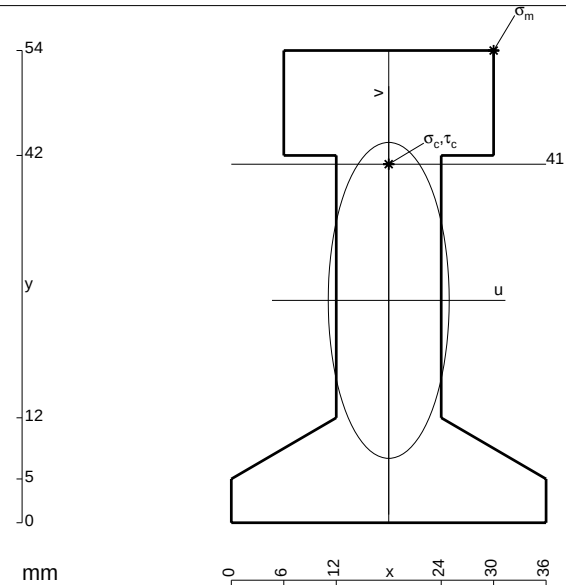
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$



$$A = 996. \text{ mm}^2$$

$$J_u = 325226. \text{ mm}^4$$

$$J_v = 47664. \text{ mm}^4$$

$$y_g = 25.43 \text{ mm}$$

$$T_y = 2660. \text{ N}$$

$$M_x = -2713200. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.57 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.4 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

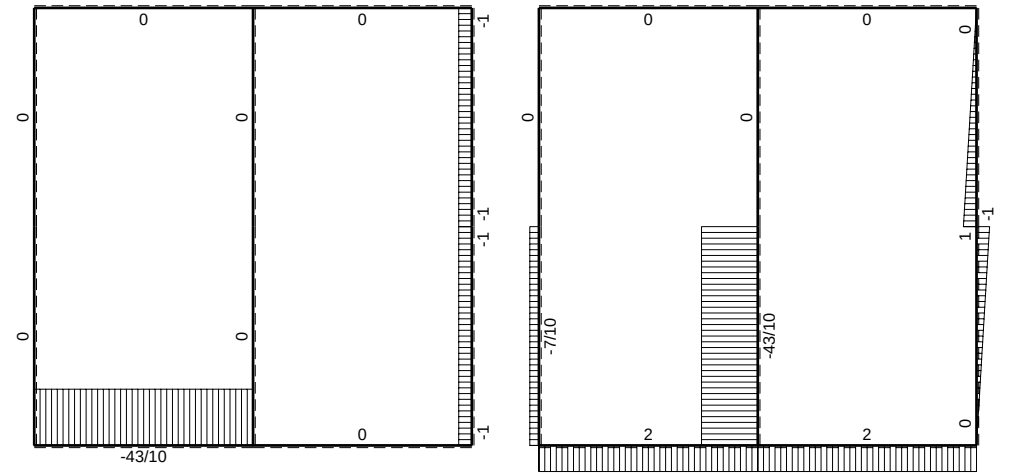
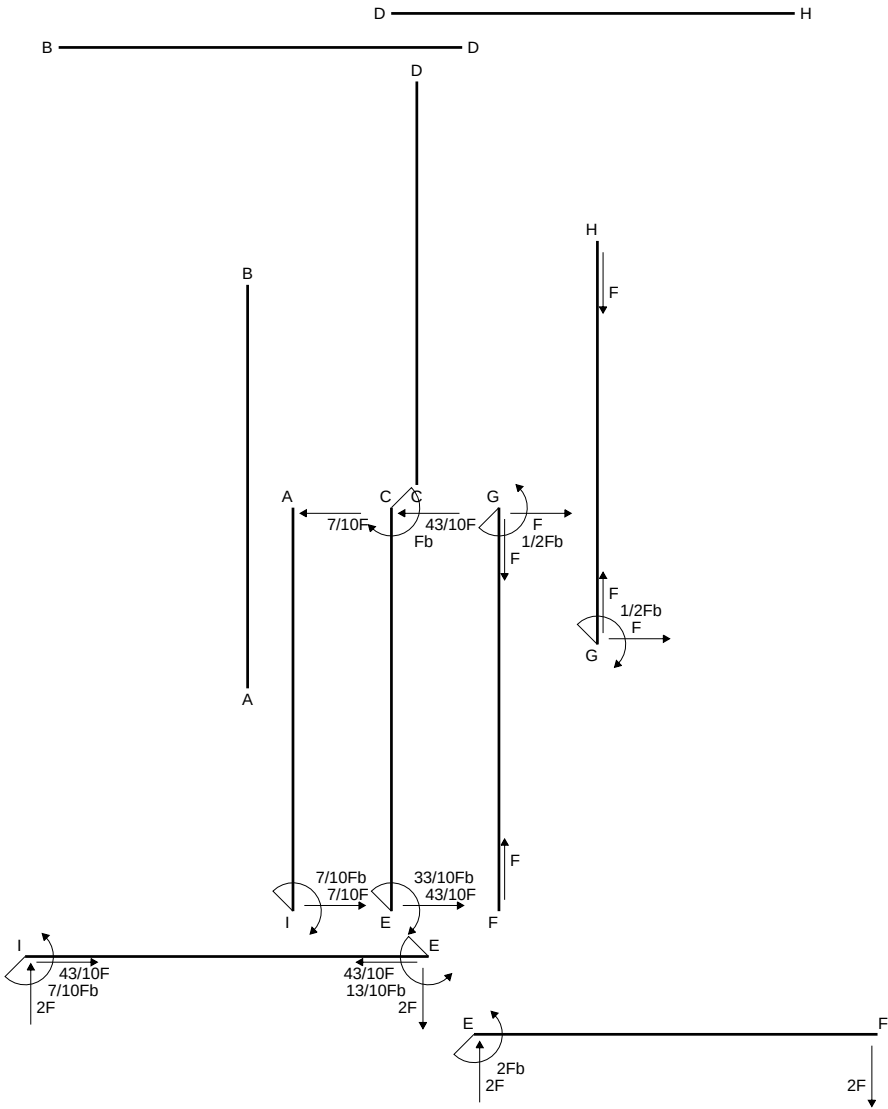
$$v_c = 15.57 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 129.9 \text{ N/mm}^2$$

$$\tau_c = 4.563 \text{ N/mm}^2$$

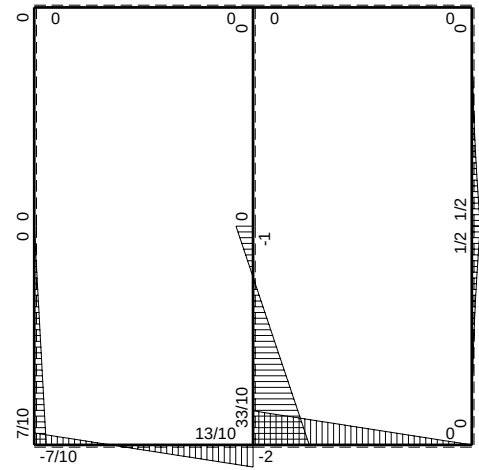
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 130.2 \text{ N/mm}^2$$

$$S = 6694. \text{ mm}^3$$

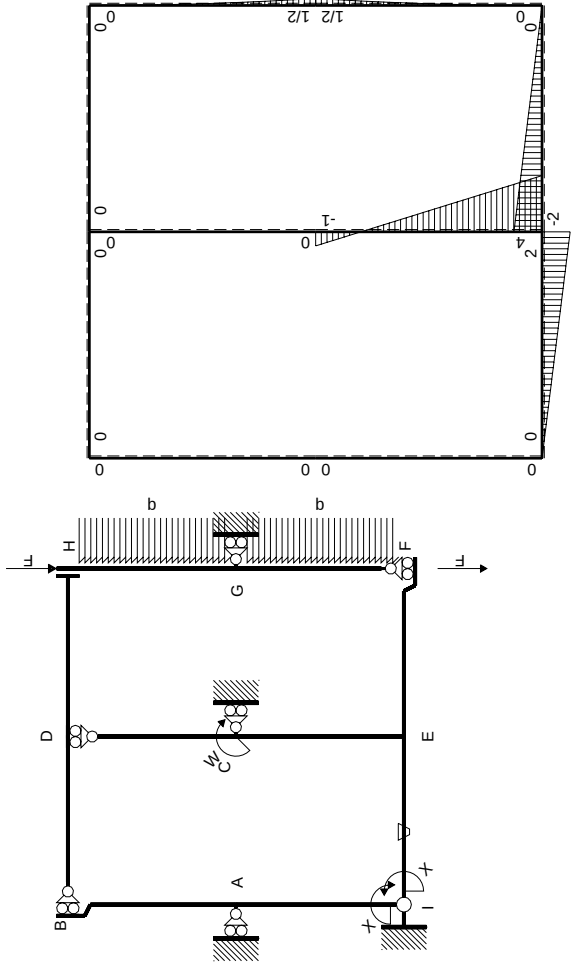


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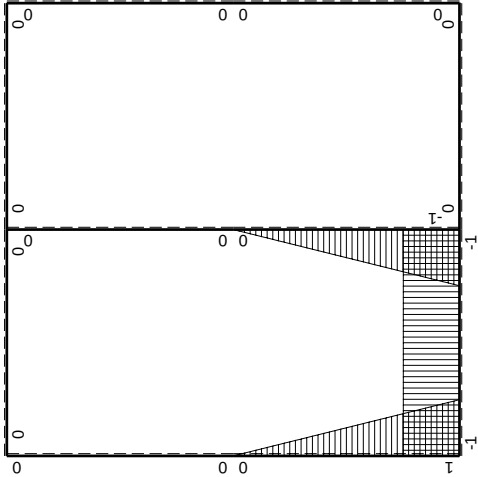


⊕ ⊖ F_b



Schema di calcolo iperstatico

$\left(\begin{array}{c} \oplus \\ \ominus \end{array} \right) M_0$ flessione da carichi assegnati



$\left(\begin{array}{c} \oplus \\ \ominus \end{array} \right) M_x$ flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-5Fx$	0	$-4Fb+9Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-5Fx$	0	$Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

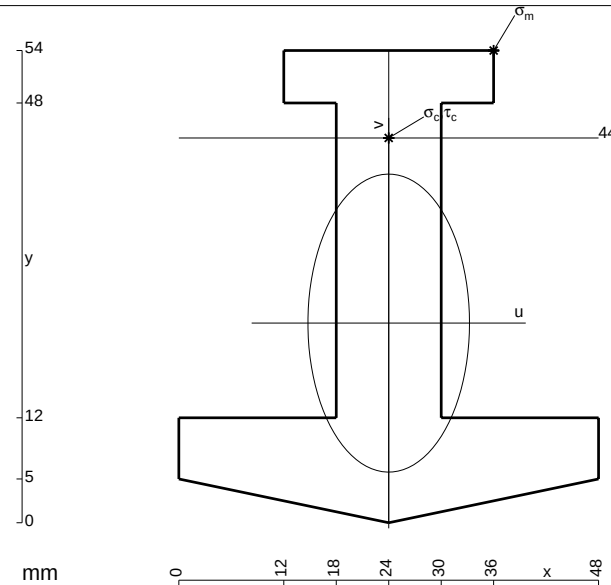
$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 9x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 9/2 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

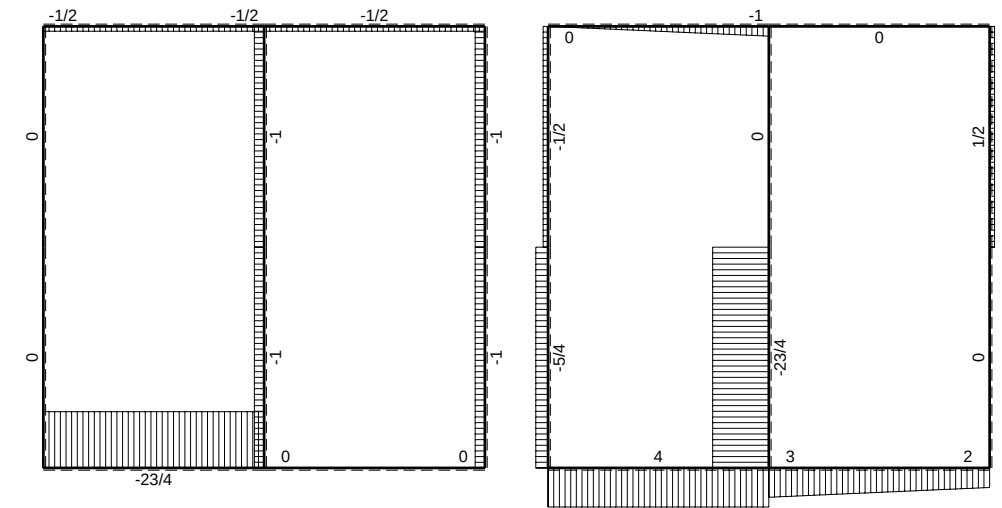
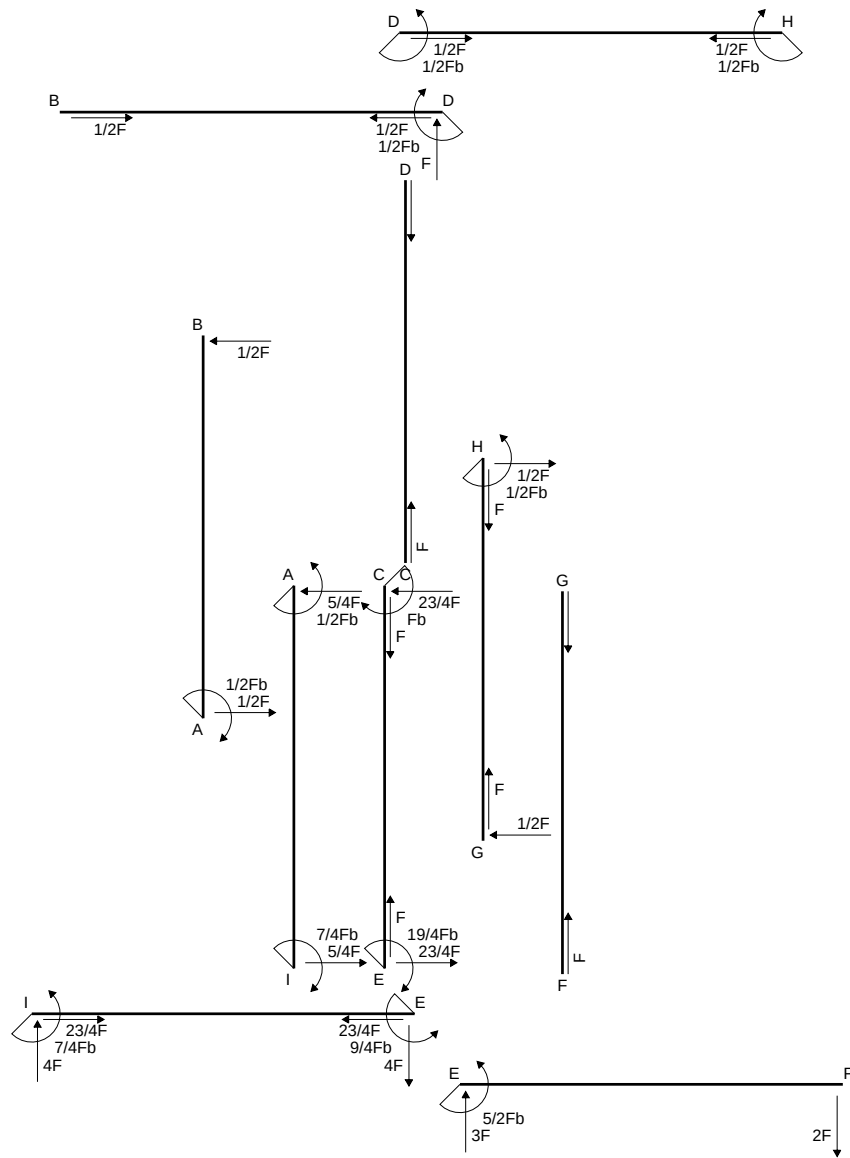
$$= (-4b + 9/2 b - 5/3 b) Fb \frac{1}{EJ} = -7/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

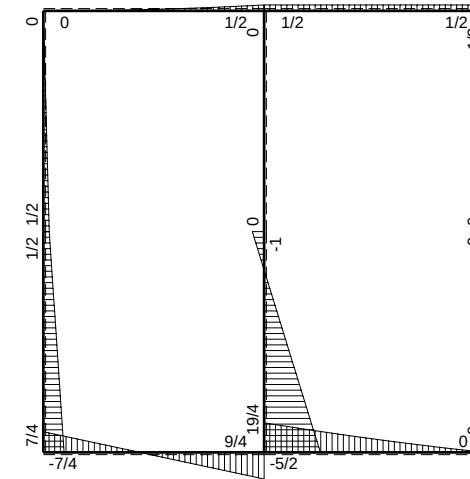
$$= (1/2 b - 5/3 b) Fb \frac{1}{EJ} = -7/6 Fb^2/EJ$$

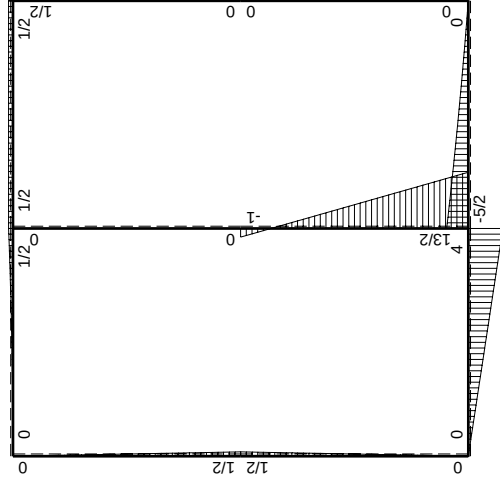
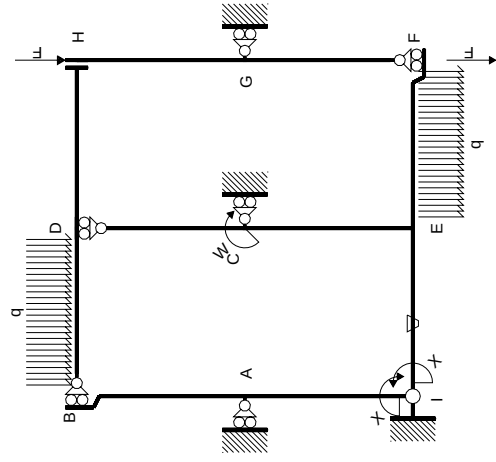


$$\begin{aligned} A &= 1032. \text{ mm}^2 \\ J_u &= 299718. \text{ mm}^4 \\ J_v &= 88128. \text{ mm}^4 \\ y_g &= 22.83 \text{ mm} \\ T_y &= 3560. \text{ N} \\ M_x &= -1922400. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 31.17 \text{ mm} \\ \sigma_m &= -Mv/J_u = 199.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 21.17 \text{ mm} \\ \sigma_c &= -Mv/J_u = 135.8 \text{ N/mm}^2 \\ \tau_c &= 5.116 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 136.1 \text{ N/mm}^2 \\ S &= 5169. \text{ mm}^3 \end{aligned}$$

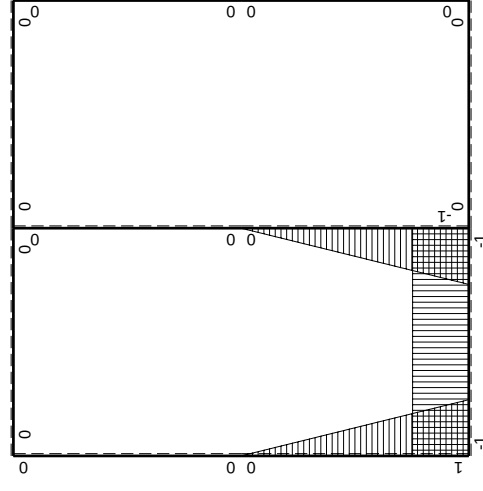


A diagram showing a positive charge, represented by a square box with a '+' sign inside. A horizontal arrow points to the left from the charge, and another horizontal arrow points to the right from the charge, labeled with the letter 'F'.





Schema di calcolo iperstatico



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2 Fb - 1/2 Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2 Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2 Fb + 3Fx - 1/2 qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx + 1/2 qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2 Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2 Fb + 1/2 Fx$	0	0	0	0		
HD b	0	$1/2 Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2 Fb$	0	0	0	0		
DB b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2 qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb + 4Fx$	Fb/EJ	$-4Fb + 4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2 Fb - 15/2 Fx$	0	$-13/2 Fb + 14Fx - 15/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3 Xb/EJ$
CE b	x/b	$Fb - 15/2 Fx$	0	$Fx - 15/2 Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2 Fx$	0	$1/2 Fx - 1/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3 Xb/EJ$
AI b	$-x/b$	$-1/2 Fb + 1/2 Fx$	0	$1/2 Fx - 1/2 Fx^2/b$	0	x^2/b^2		
	totali						$-35/12 Fb^2/EJ$	$5/3 Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4 Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 14x/b - 15/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 7x^2/b - 5/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 7b - 5/2 b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 15/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 5/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

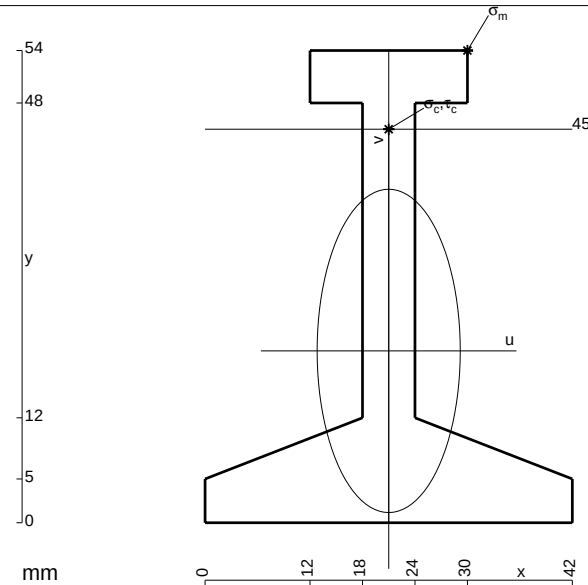
$$= (1/2 b - 5/2 b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

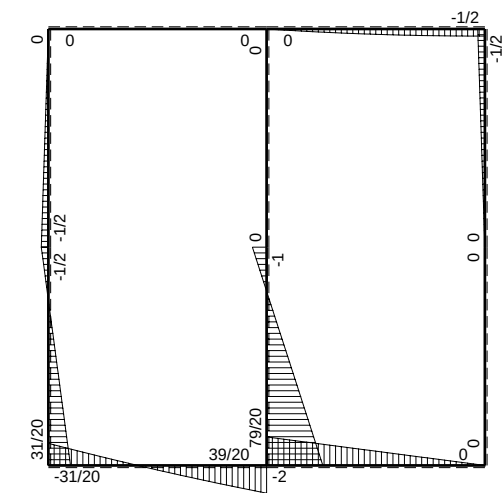
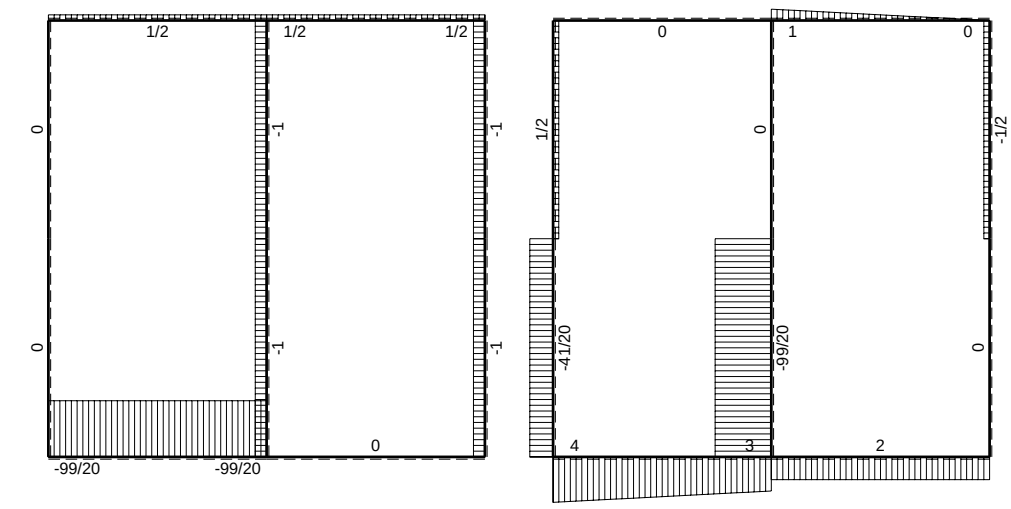
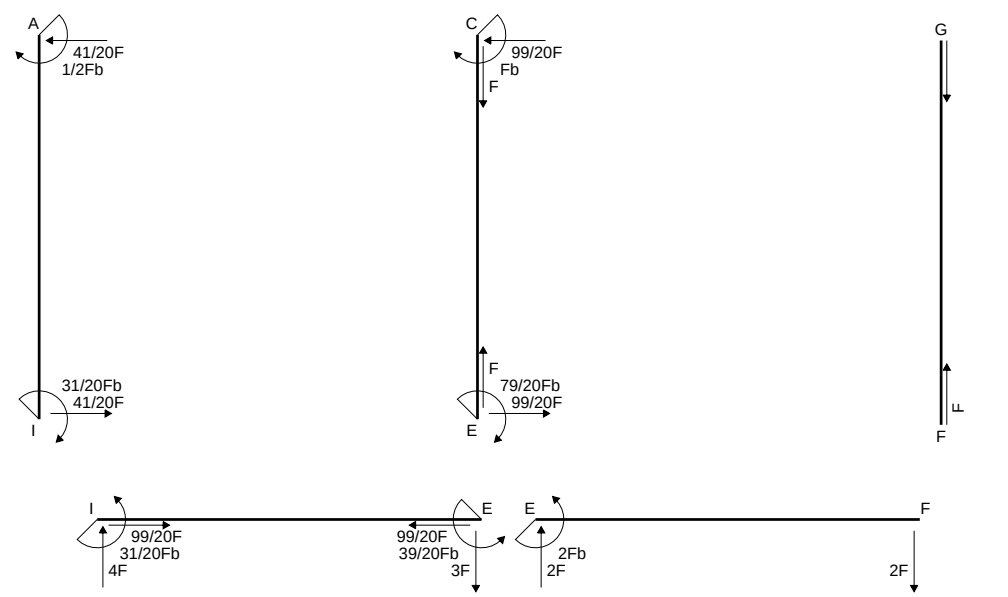
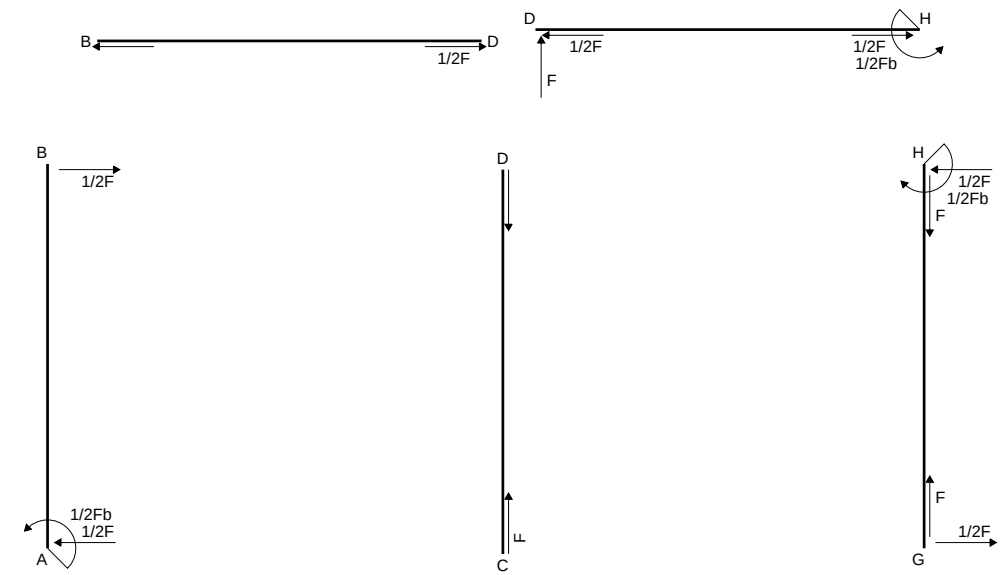
$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$\begin{aligned} A &= 702. \text{ mm}^2 \\ J_u &= 239989. \text{ mm}^4 \\ J_v &= 47034. \text{ mm}^4 \\ y_g &= 19.65 \text{ mm} \\ T_y &= 2970. \text{ N} \\ M_x &= -1460250. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 34.35 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209. \text{ N/mm}^2 \\ x_c &= 21. \text{ mm} \\ y_c &= 45. \text{ mm} \\ v_c &= 25.35 \text{ mm} \\ \sigma_c &= -Mv/J_u = 154.2 \text{ N/mm}^2 \\ \tau_c &= 7.981 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 154.9 \text{ N/mm}^2 \\ S &= 3869. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-13/2Fx$	0	$-11/2Fb+12Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-13/2Fx$	0	$Fx-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 12x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 6x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 6b - 13/6 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

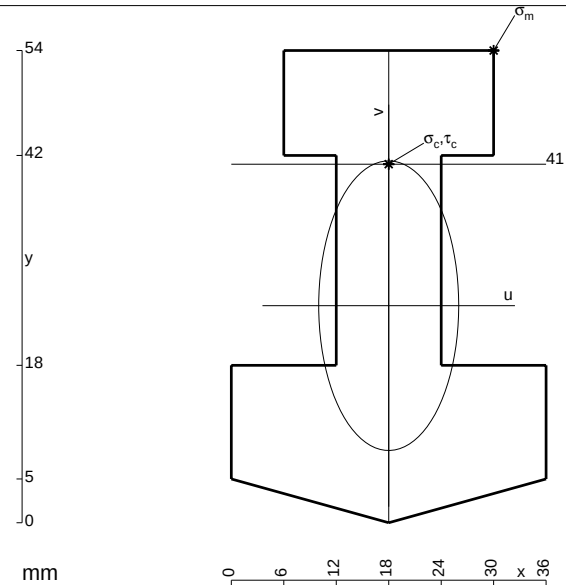
$$= (1/2 b - 13/6 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 1134. \text{ mm}^2$$

$$J_u = 311054. \text{ mm}^4$$

$$J_v = 72684. \text{ mm}^4$$

$$y_g = 24.82 \text{ mm}$$

$$T_y = 3660. \text{ N}$$

$$M_x = -2342400. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 29.18 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.7 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

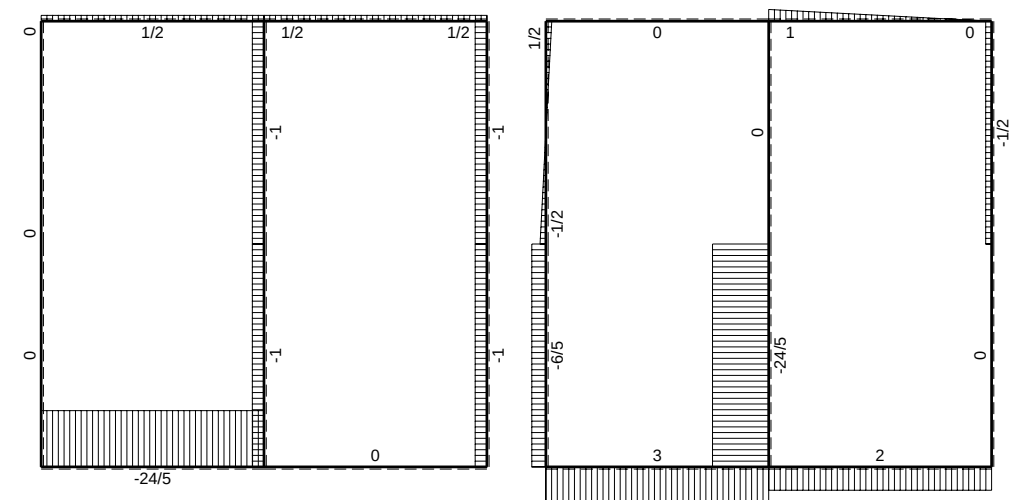
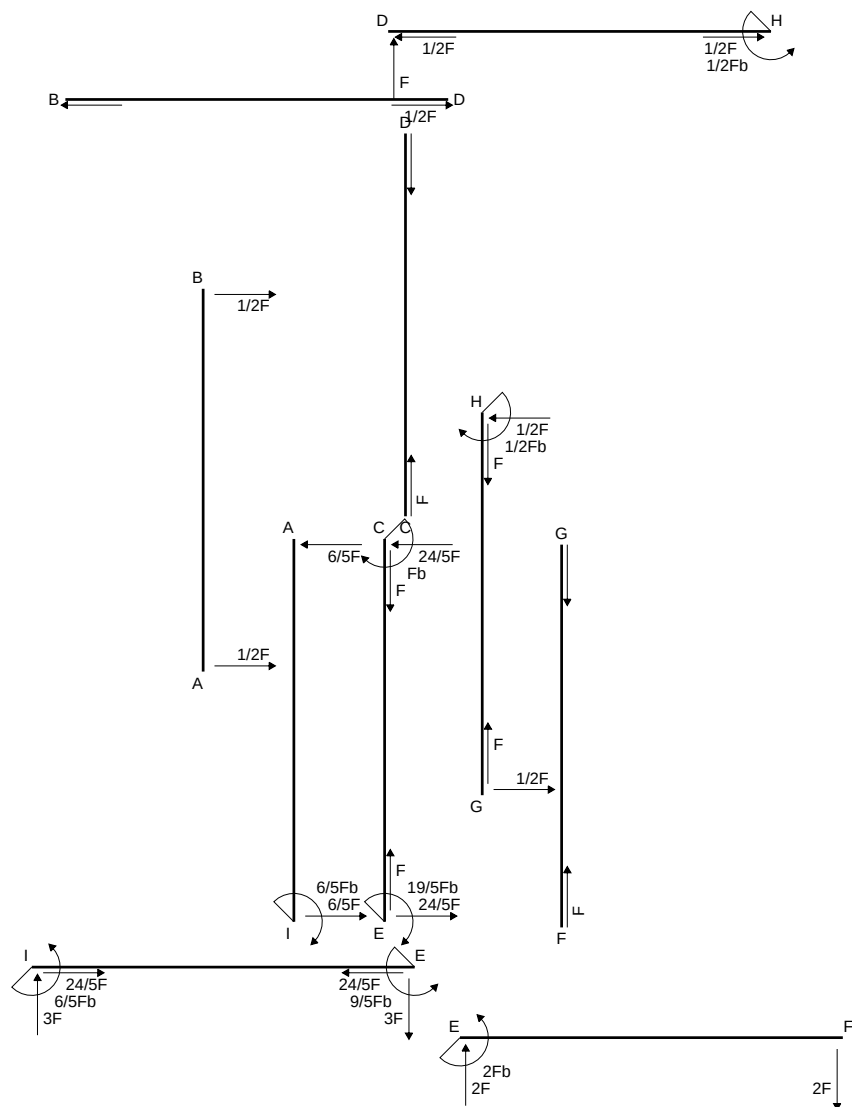
$$v_c = 16.18 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 121.8 \text{ N/mm}^2$$

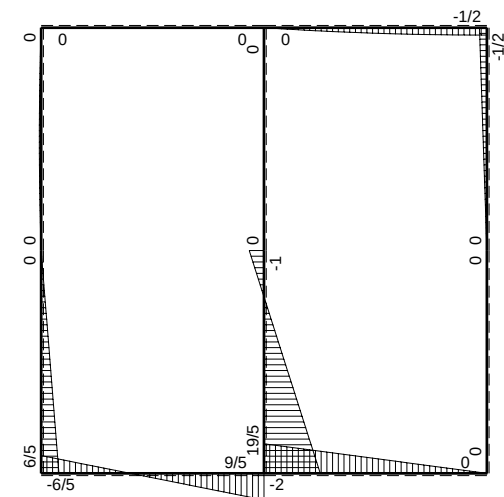
$$\tau_c = 6.742 \text{ N/mm}^2$$

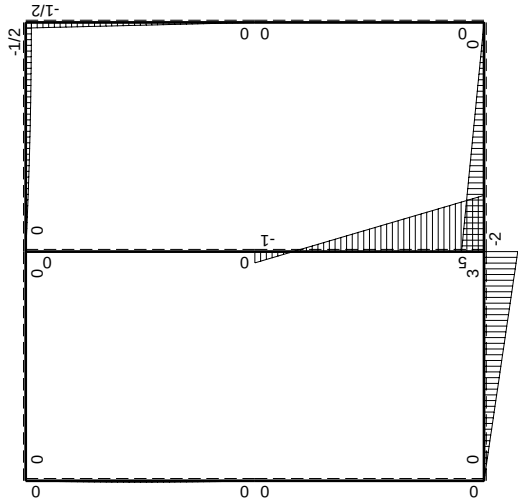
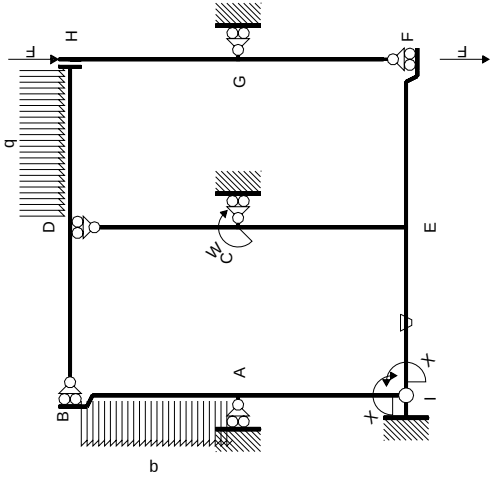
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 122.4 \text{ N/mm}^2$$

$$S = 6876. \text{ mm}^3$$


$$\leftarrow \boxed{+} \rightarrow_F$$

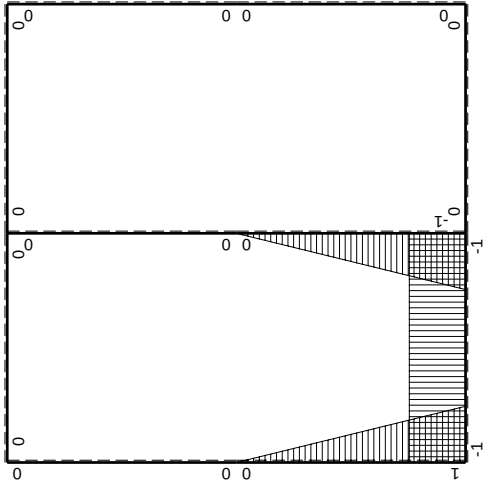
↑ + ↓ F





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

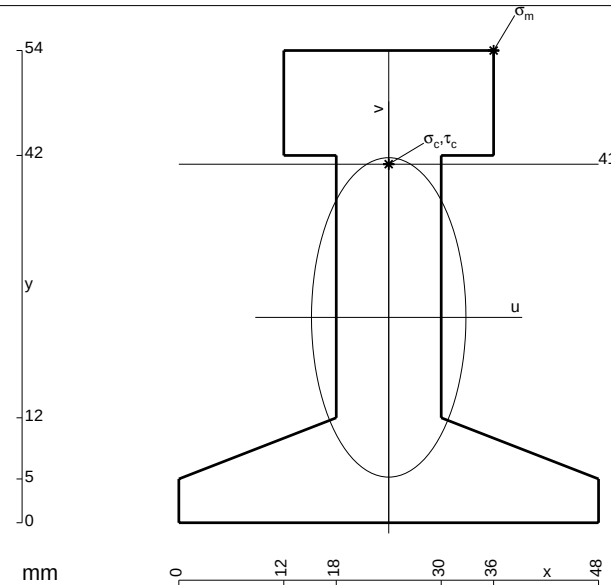
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$



$$A = 1098. \text{ mm}^2$$

$$J_u = 366595. \text{ mm}^4$$

$$J_v = 85644. \text{ mm}^4$$

$$y_g = 23.48 \text{ mm}$$

$$T_y = 3940. \text{ N}$$

$$M_x = -2758000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.52 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 229.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

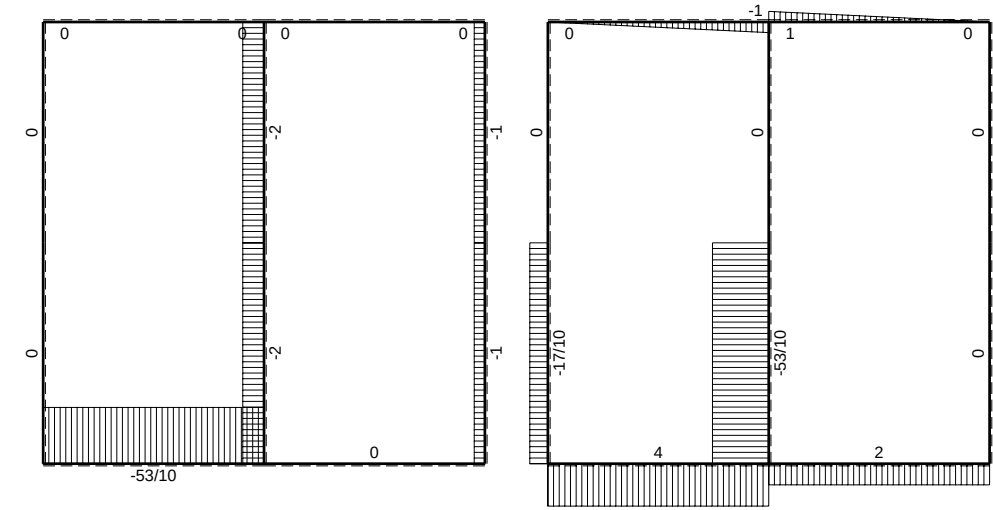
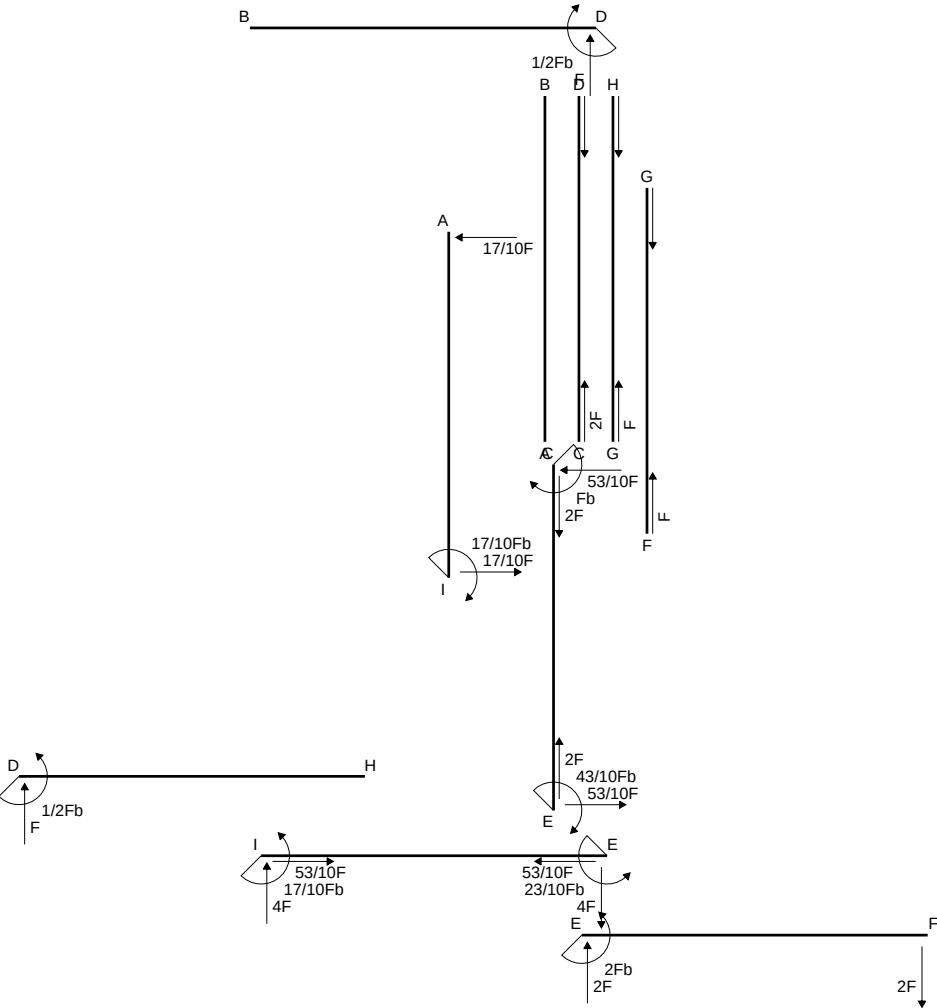
$$v_c = 17.52 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 131.8 \text{ N/mm}^2$$

$$\tau_c = 6.518 \text{ N/mm}^2$$

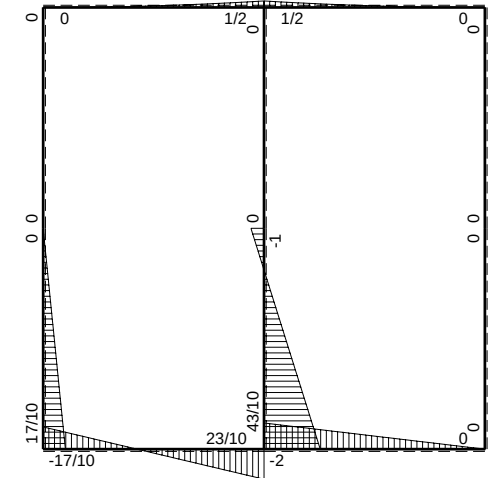
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 132.3 \text{ N/mm}^2$$

$$S = 7278. \text{ mm}^3$$

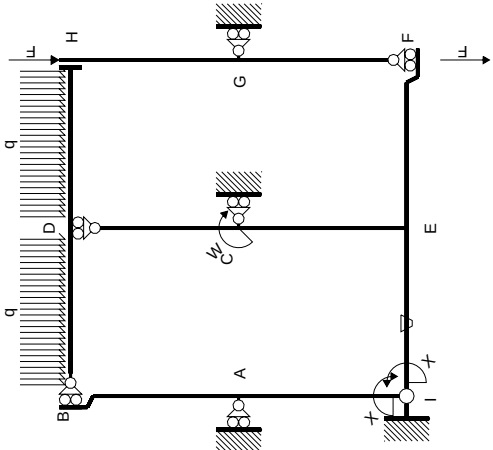


← ⊕ → F

↑ ⊕ ↓ F

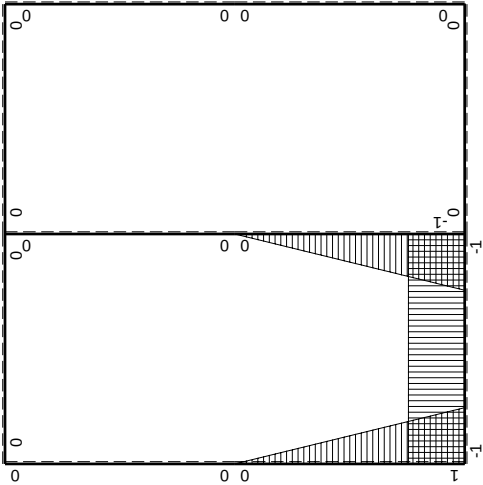
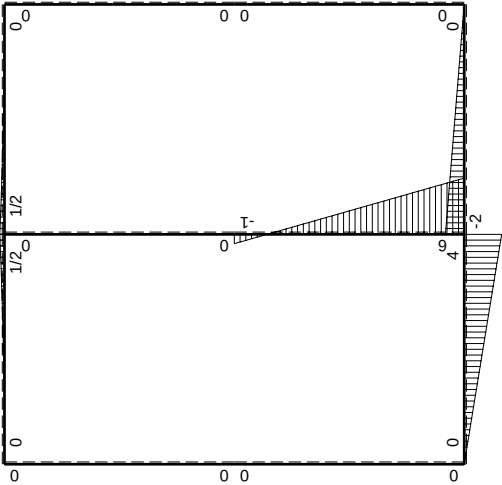


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-7Fx$	0	$-6Fb+13Fx-7Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-7Fx$	0	$Fx-7Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-17/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$17/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

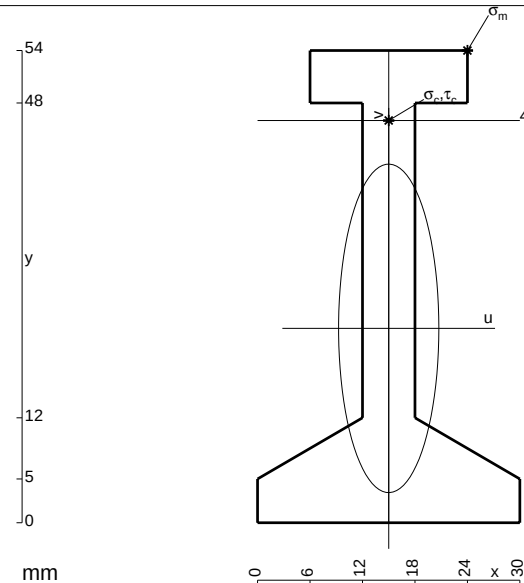
$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 13x/b - 7x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 13/2 x^2/b - 7/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

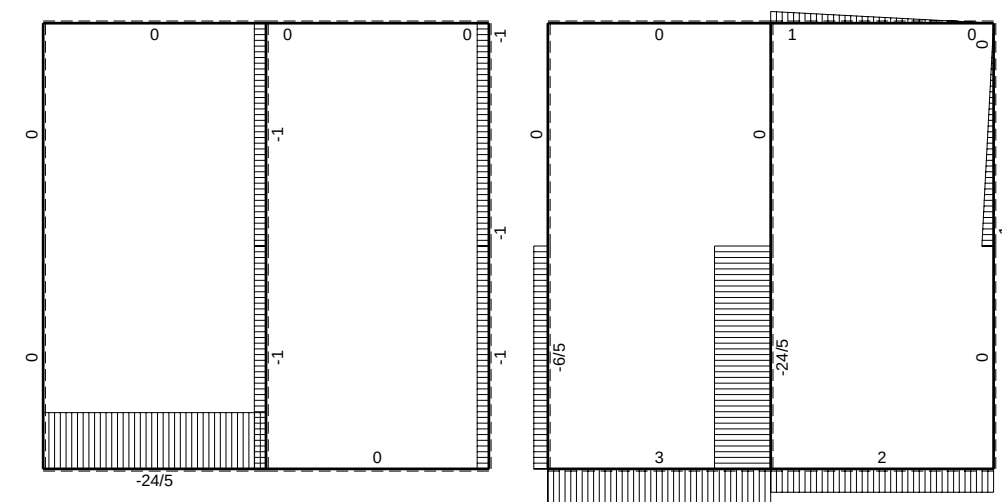
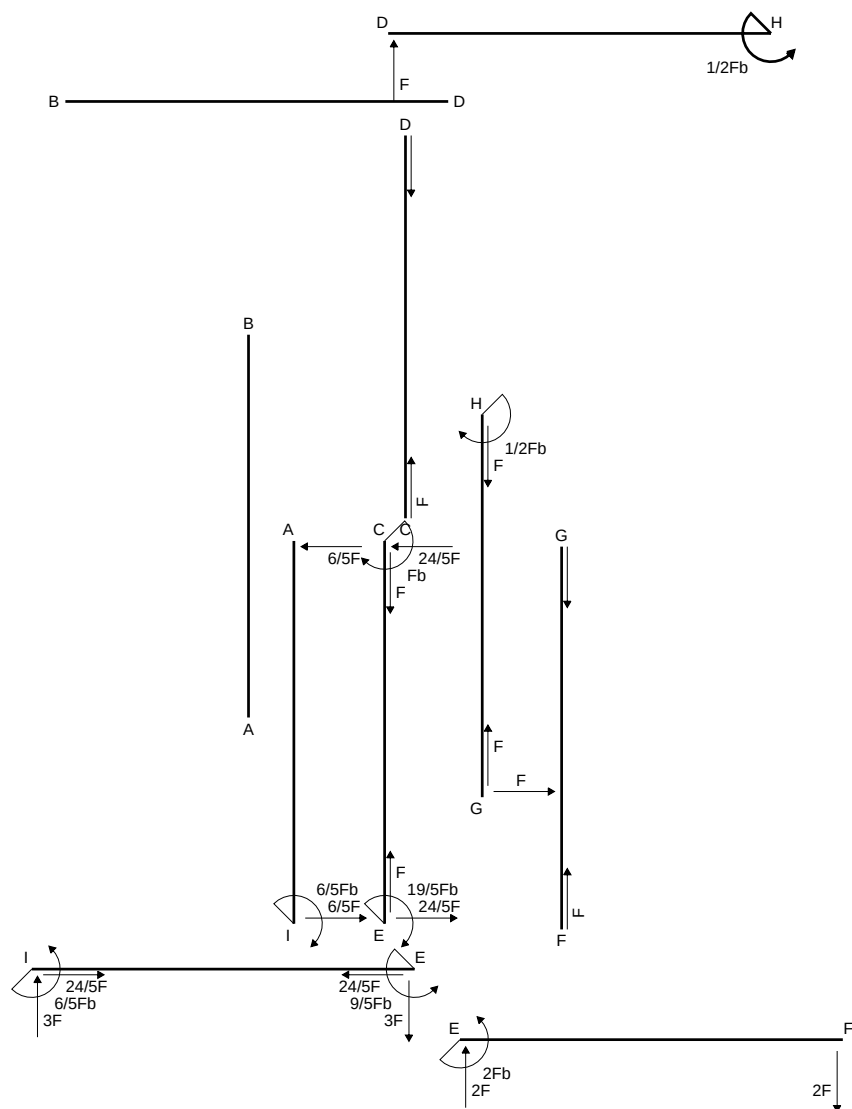
$$= (-6b + 13/2 b - 7/3 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 7x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 7/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

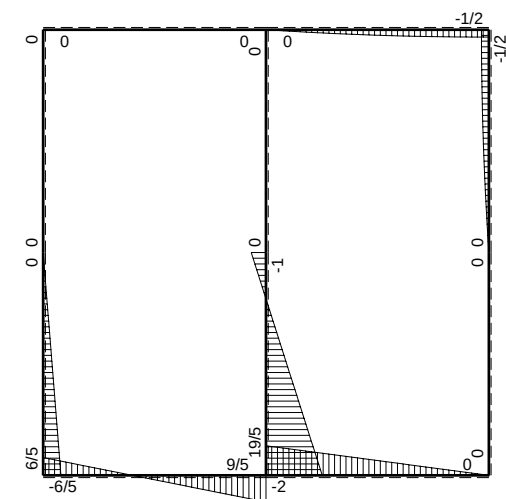
$$= (1/2 b - 7/3 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$



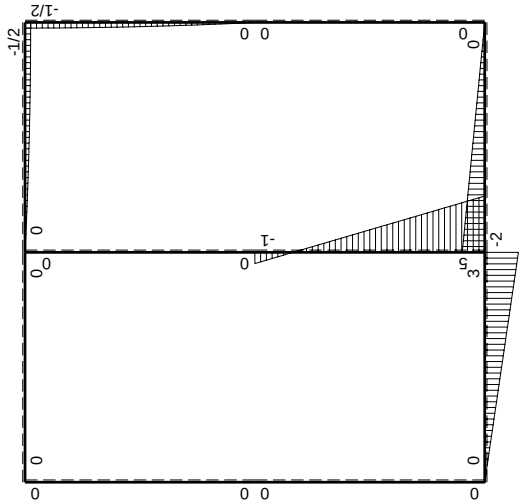
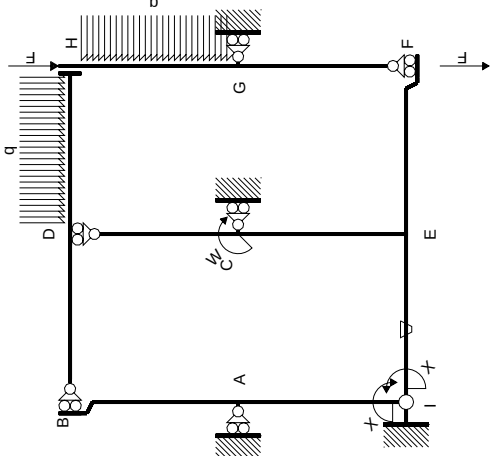
$$\begin{aligned} A &= 600. \text{ mm}^2 \\ J_u &= 211747. \text{ mm}^4 \\ J_v &= 19728. \text{ mm}^4 \\ y_g &= 22.23 \text{ mm} \\ T_y &= 2120. \text{ N} \\ M_x &= -1590000. \text{ Nmm} \\ x_m &= 24. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 9. \text{ mm} \\ v_m &= 31.77 \text{ mm} \\ \sigma_m &= -Mv/J_u = 238.6 \text{ N/mm}^2 \\ x_c &= 15. \text{ mm} \\ y_c &= 46. \text{ mm} \\ v_c &= 23.77 \text{ mm} \\ \sigma_c &= -Mv/J_u = 178.5 \text{ N/mm}^2 \\ \tau_c &= 5.681 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 178.8 \text{ N/mm}^2 \\ S &= 3405. \text{ mm}^3 \end{aligned}$$


$$\leftarrow \boxed{+} \rightarrow_F$$

↑ $\square$ ↓ F

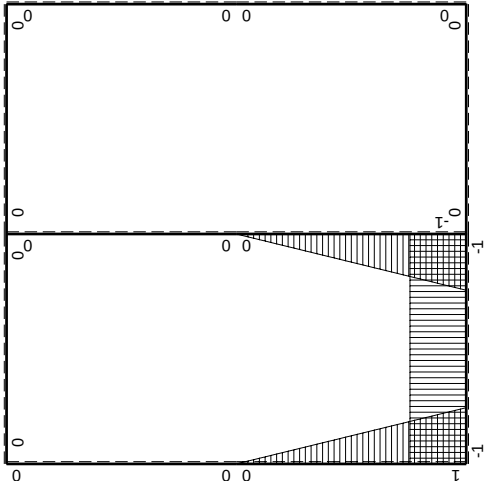


 Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

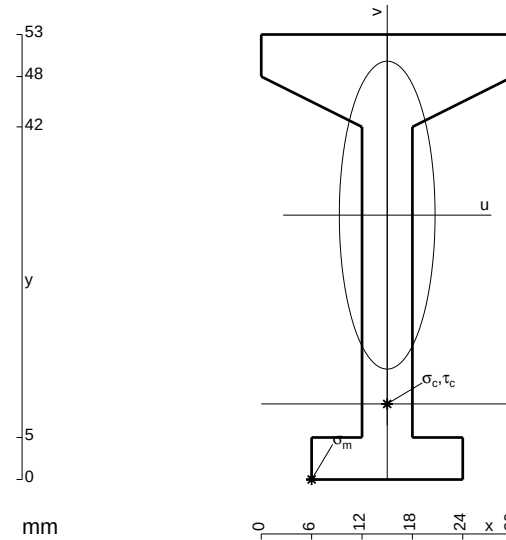
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x0} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{x0} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$



$$A = 570. \text{ mm}^2$$

$$J_u = 191825. \text{ mm}^4$$

$$J_v = 18558. \text{ mm}^4$$

$$y_g = 31.49 \text{ mm}$$

$$T_y = 1540. \text{ N}$$

$$M_x = -1216600. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -31.49 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.7 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

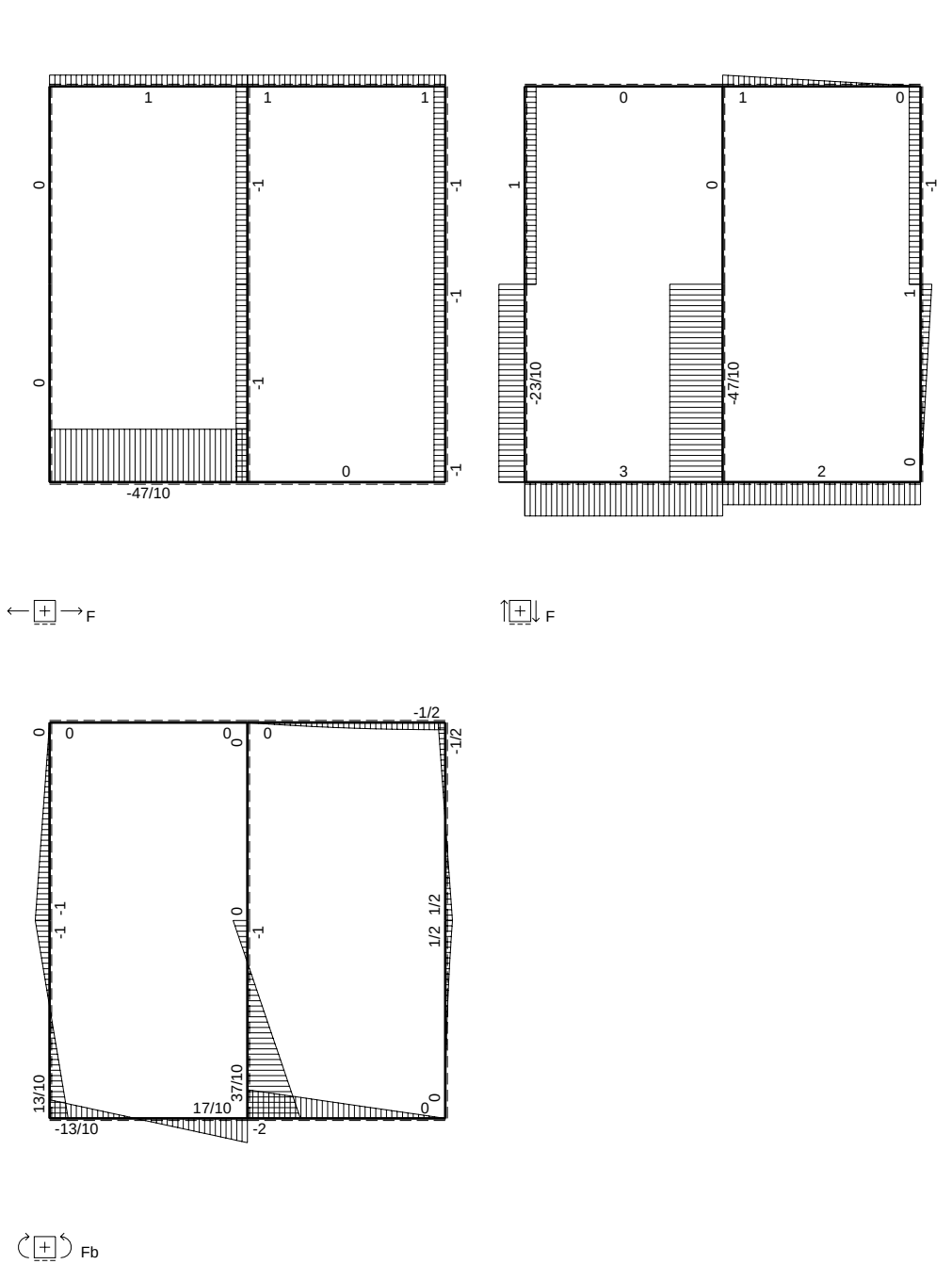
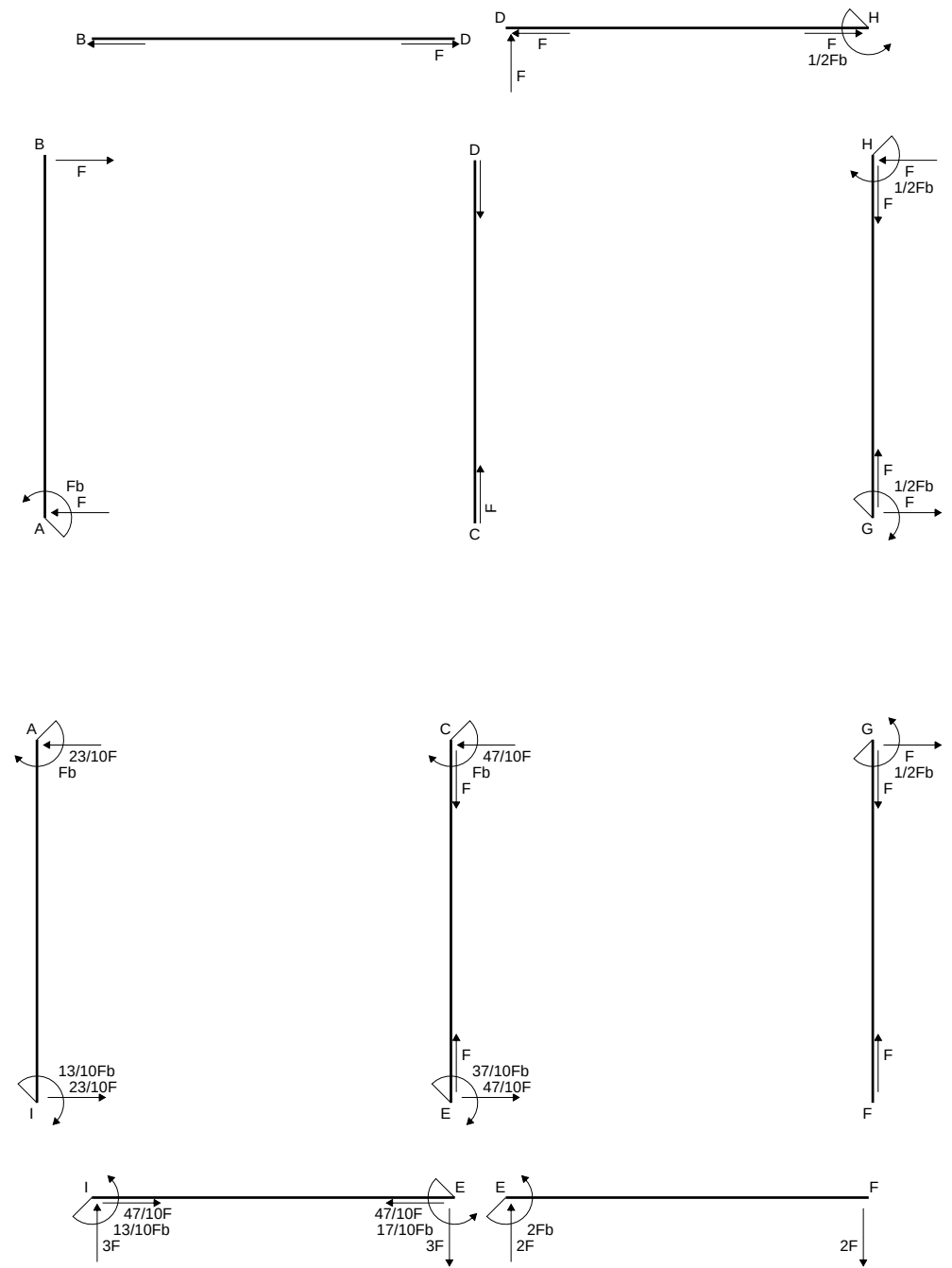
$$v_c = -22.49 \text{ mm}$$

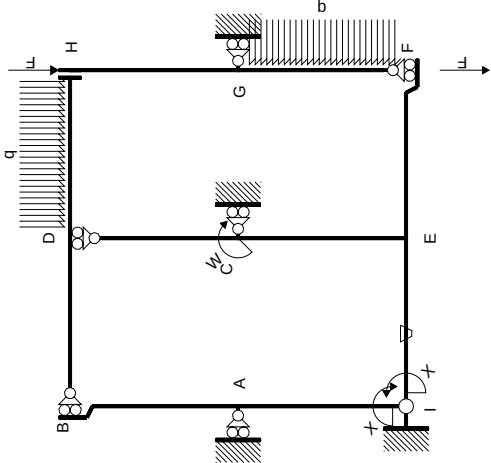
$$\sigma_c = -Mv/J_u = -142.6 \text{ N/mm}^2$$

$$\tau_c = 4.277 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 142.8 \text{ N/mm}^2$$

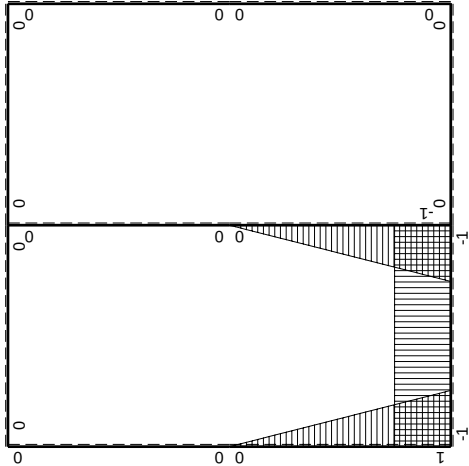
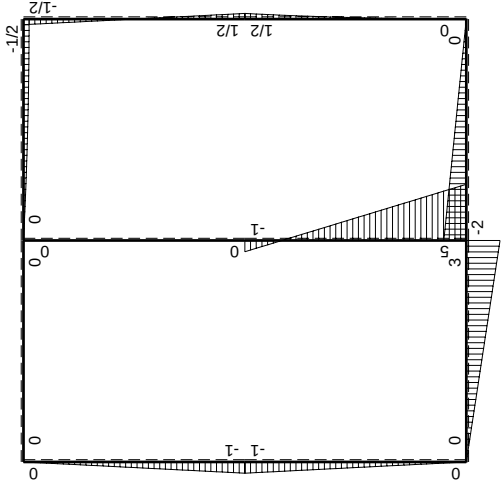
$$S = 3197. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x_0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x_0} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

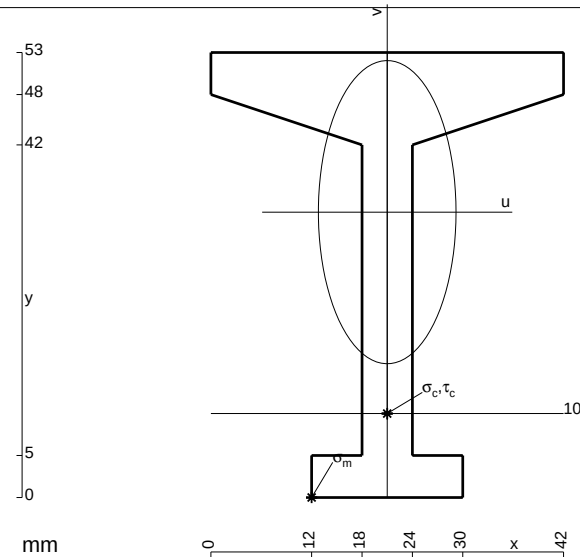
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{x_0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 666. \text{ mm}^2$$

$$J_u = 217134. \text{ mm}^4$$

$$J_v = 44766. \text{ mm}^4$$

$$y_g = 33.99 \text{ mm}$$

$$T_y = 1580. \text{ N}$$

$$M_x = -1327200. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -33.99 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -207.7 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

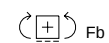
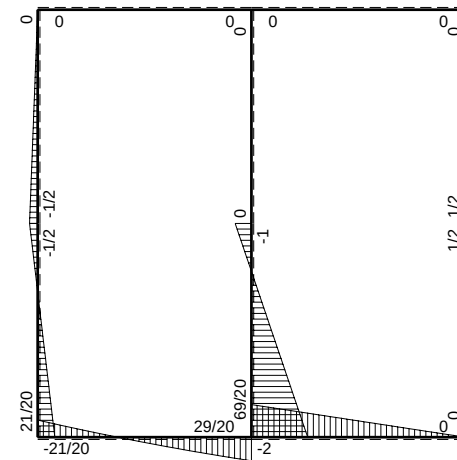
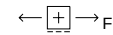
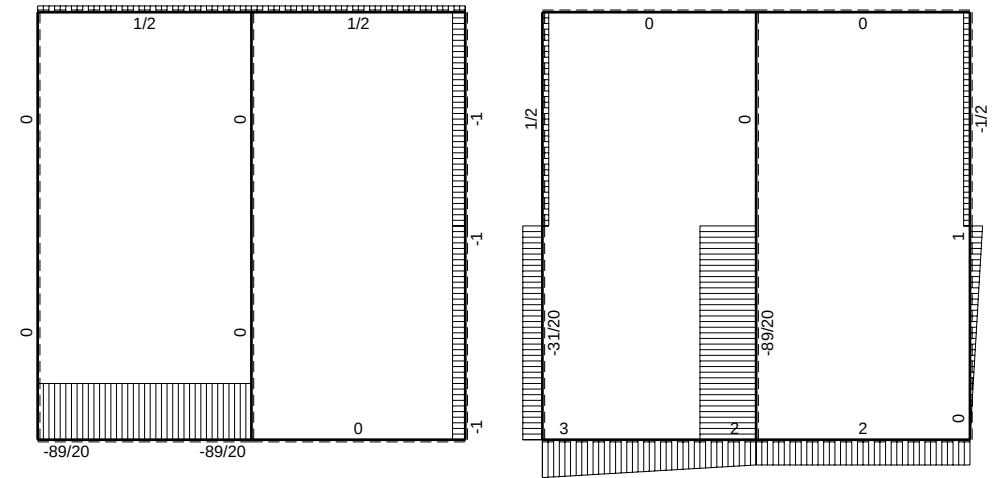
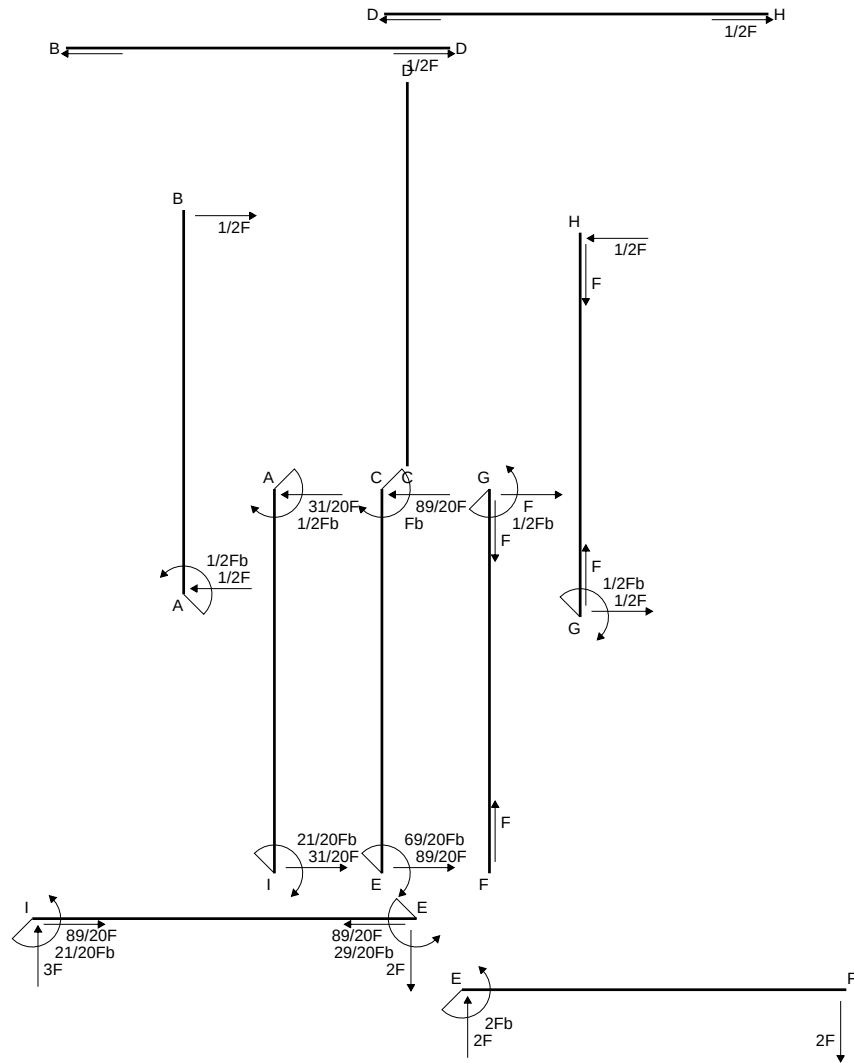
$$v_c = -23.99 \text{ mm}$$

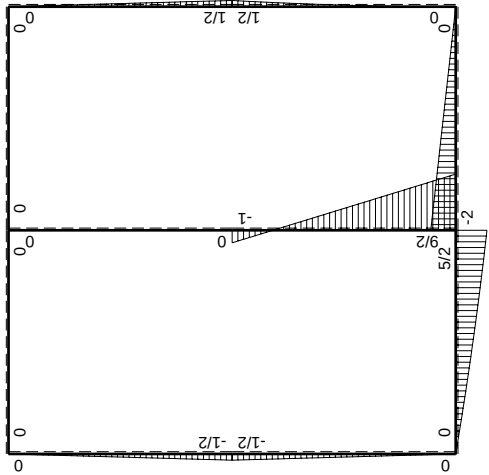
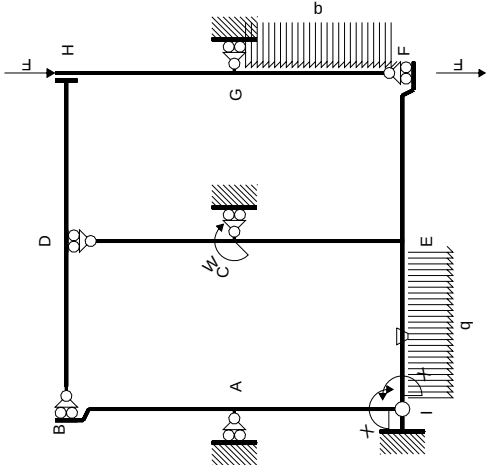
$$\sigma_c = -Mv/J_u = -146.6 \text{ N/mm}^2$$

$$\tau_c = 4.4 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 146.8 \text{ N/mm}^2$$

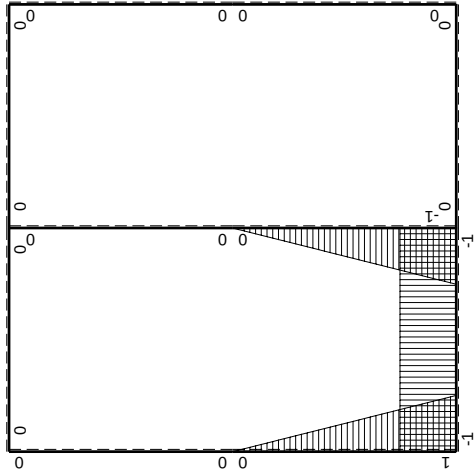
$$S = 3628. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-11/2Fx$	0	$-9/2Fb+10Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-11/2Fx$	0	$Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$21/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 10x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 5x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 5b - 11/6 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

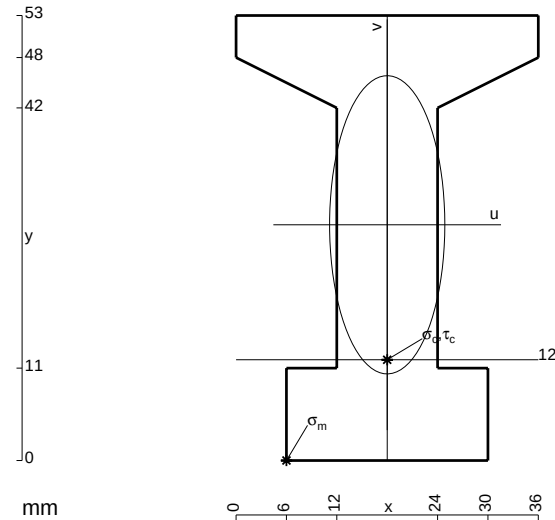
$$= (1/2 b - 11/6 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 960. \text{ mm}^2$$

$$J_u = 302931. \text{ mm}^4$$

$$J_v = 45216. \text{ mm}^4$$

$$y_g = 28.08 \text{ mm}$$

$$T_y = 2620. \text{ N}$$

$$M_x = -2358000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.08 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218.5 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

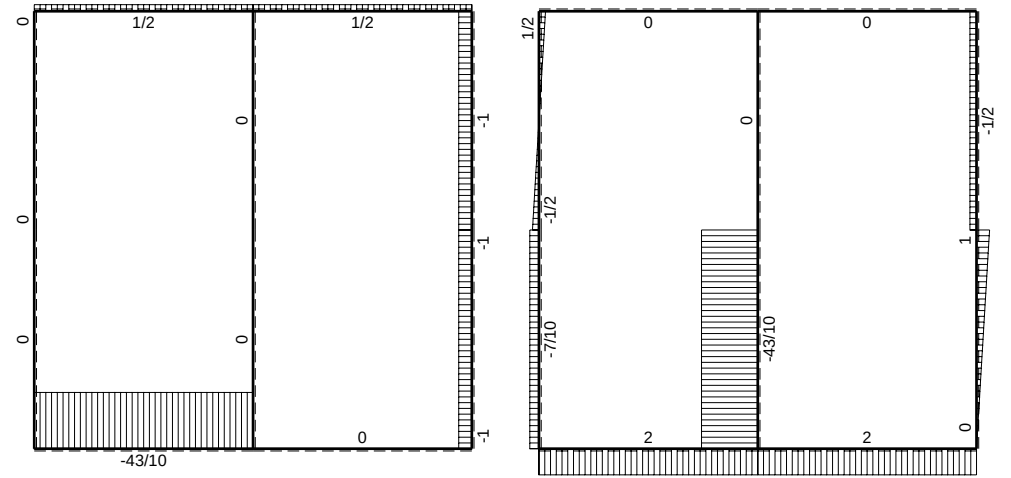
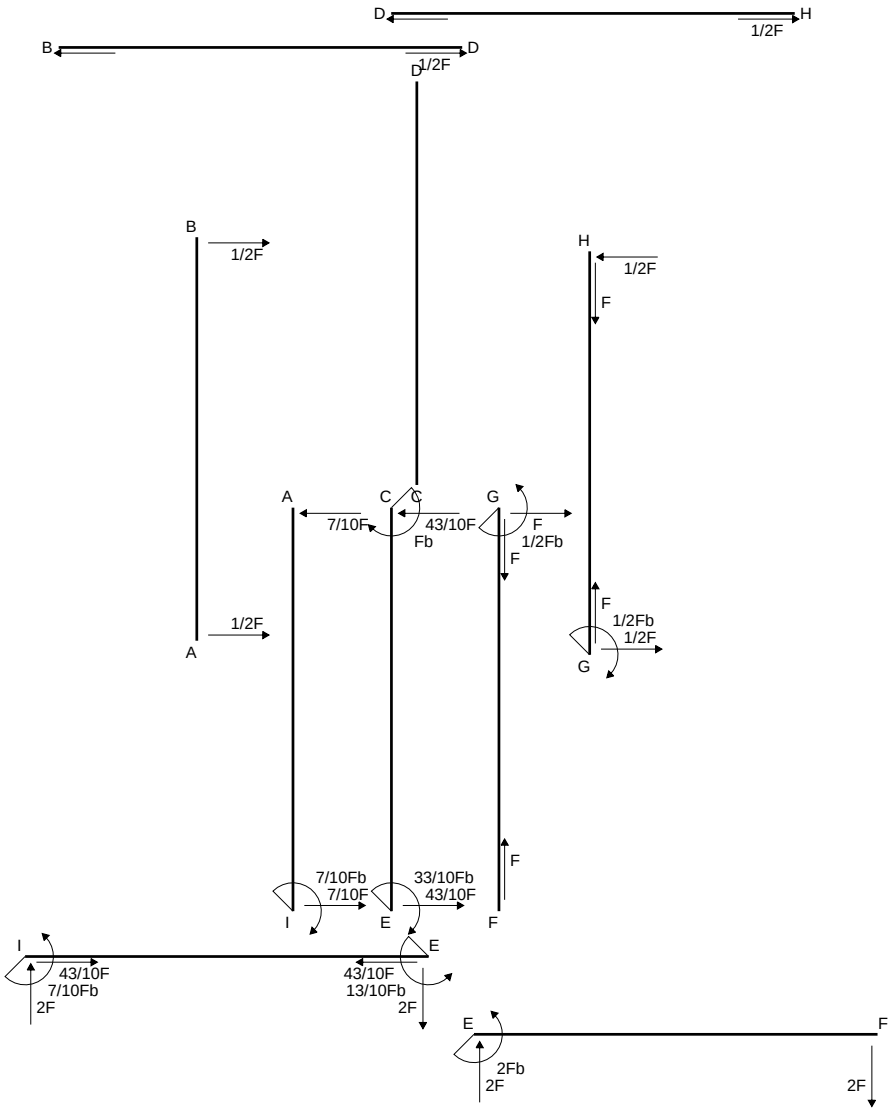
$$v_c = -16.08 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -125.1 \text{ N/mm}^2$$

$$\tau_c = 4.439 \text{ N/mm}^2$$

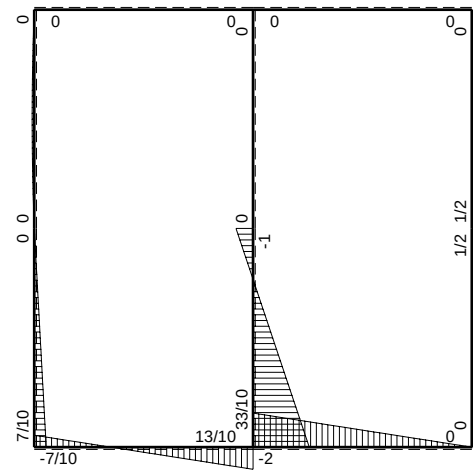
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 125.4 \text{ N/mm}^2$$

$$S = 6159. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ F_b

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-5Fx$	0	$-4Fb+9Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-5Fx$	0	$Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x\theta} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

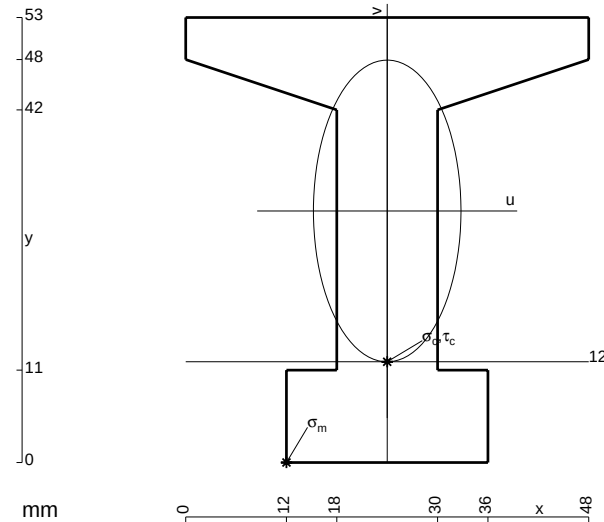
$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x\theta} = \int_0^b (-4 + 9x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 9/2 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

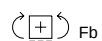
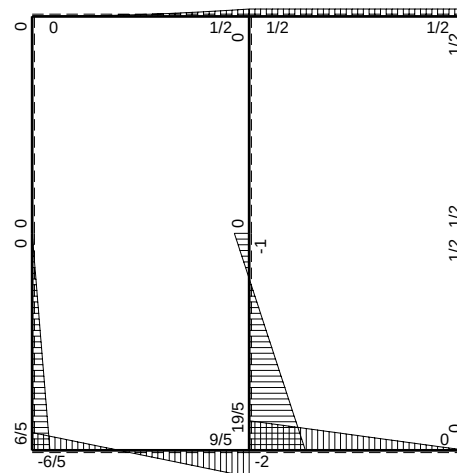
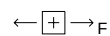
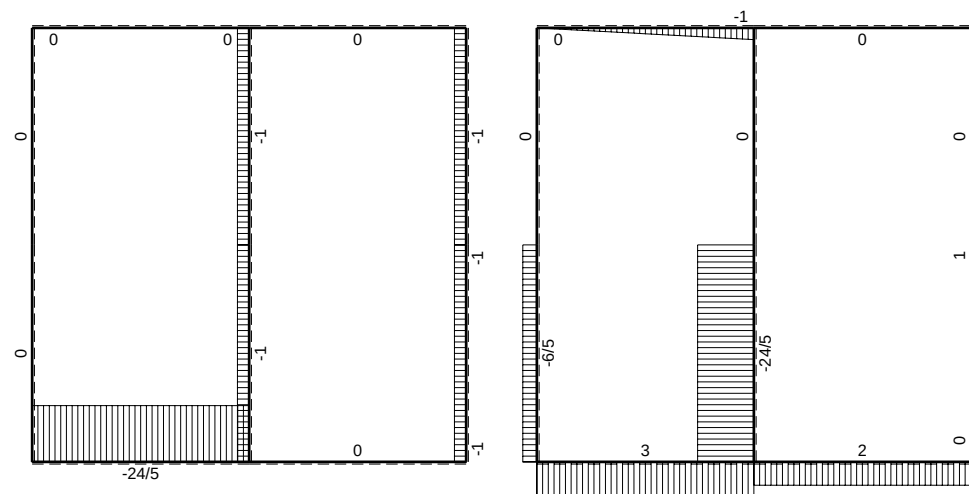
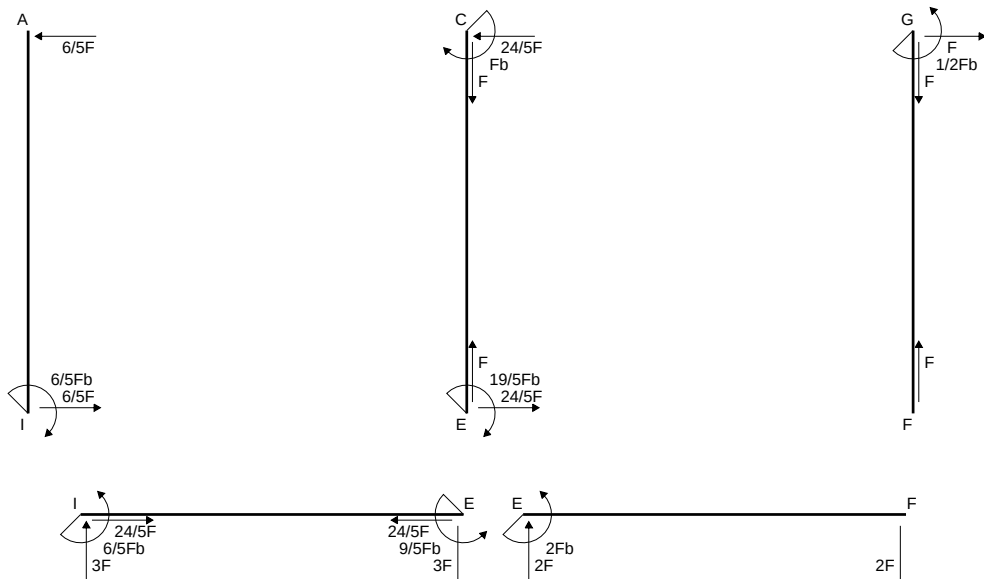
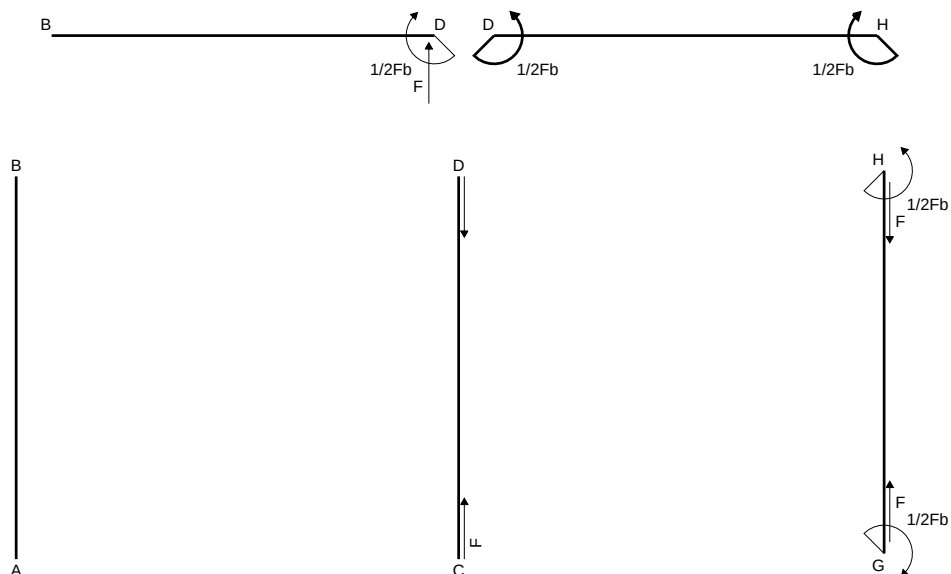
$$= (-4b + 9/2 b - 5/3 b) Fb \frac{1}{EJ} = -7/6 Fb^2/EJ$$

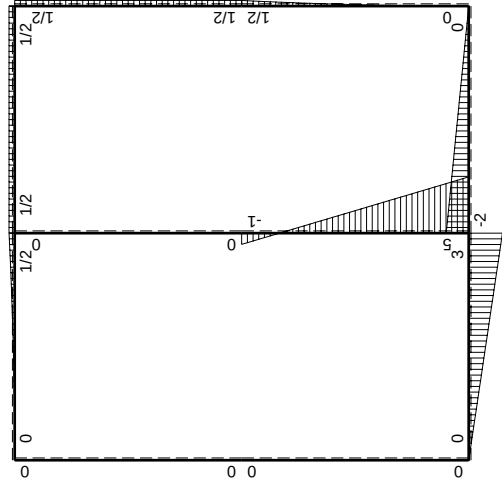
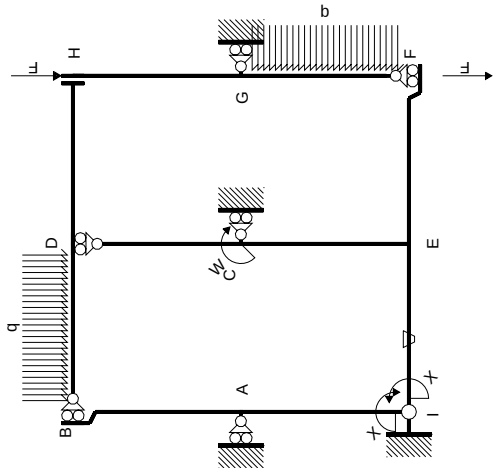
$$L_{CE}^{x\theta} = \int_0^b (x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 5/3 b) Fb \frac{1}{EJ} = -7/6 Fb^2/EJ$$



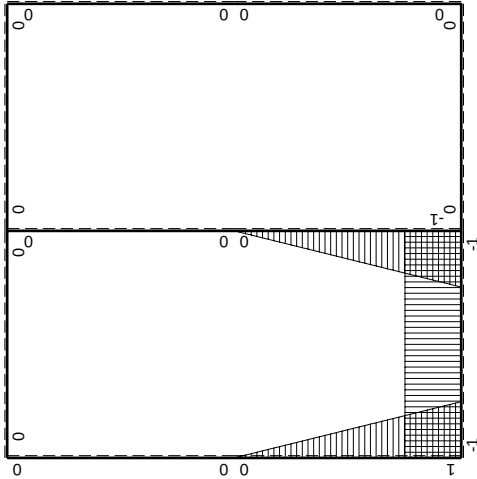
$$\begin{aligned} A &= 1056. \text{ mm}^2 \\ J_u &= 341114. \text{ mm}^4 \\ J_v &= 81576. \text{ mm}^4 \\ y_g &= 29.96 \text{ mm} \\ T_y &= 2740. \text{ N} \\ M_x &= -2603000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -29.96 \text{ mm} \\ \sigma_m &= -Mv/J_u = -228.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -17.96 \text{ mm} \\ \sigma_c &= -Mv/J_u = -137.1 \text{ N/mm}^2 \\ \tau_c &= 4.471 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 137.3 \text{ N/mm}^2 \\ S &= 6679. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

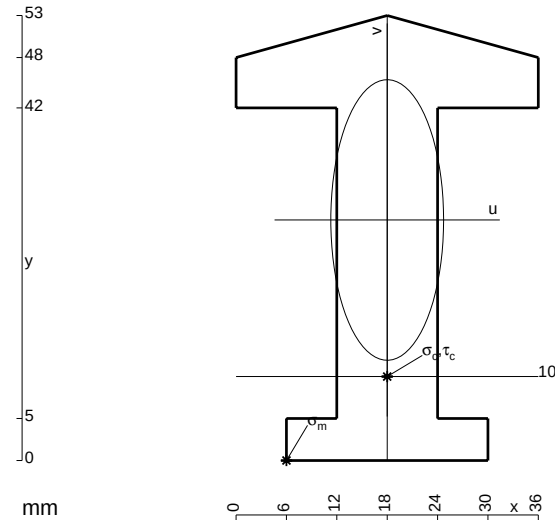
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$



$$A = 870. \text{ mm}^2$$

$$J_u = 243005. \text{ mm}^4$$

$$J_v = 39276. \text{ mm}^4$$

$$y_g = 28.65 \text{ mm}$$

$$T_y = 2020. \text{ N}$$

$$M_x = -202000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.65 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -238.1 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

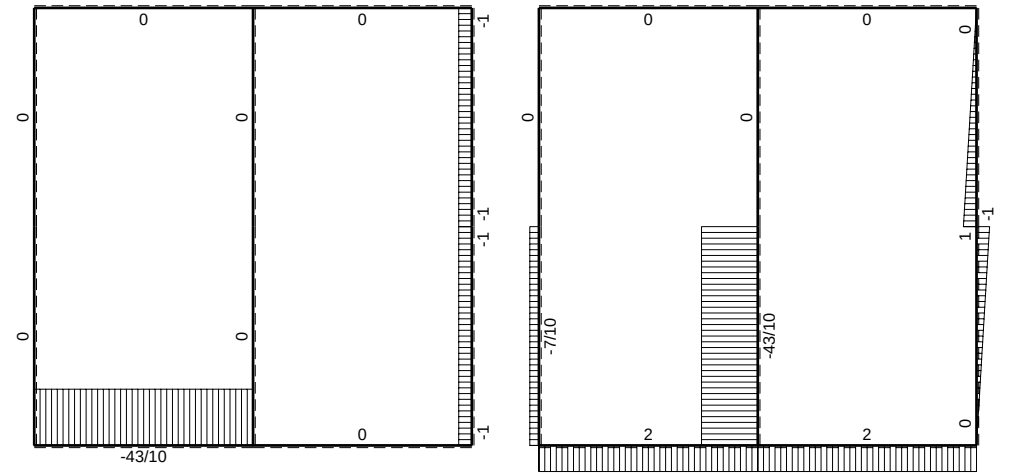
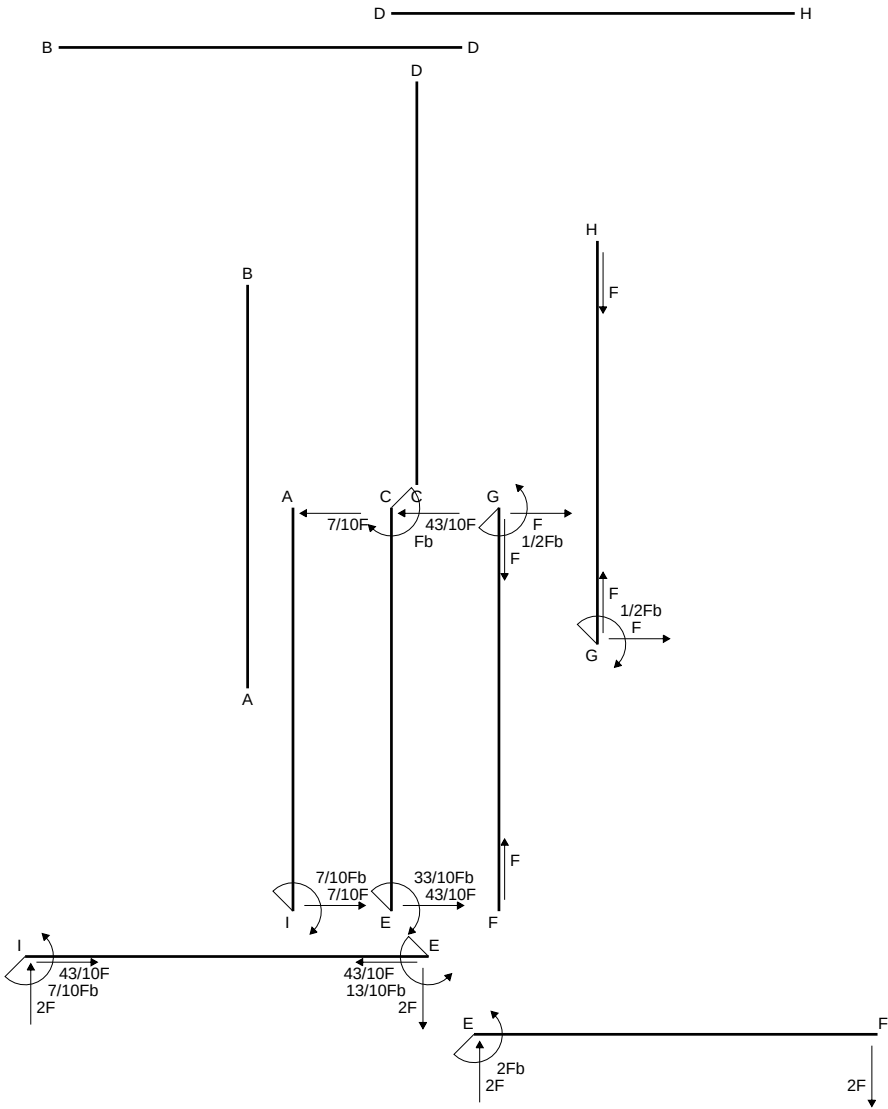
$$v_c = -18.65 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -155. \text{ N/mm}^2$$

$$\tau_c = 3.053 \text{ N/mm}^2$$

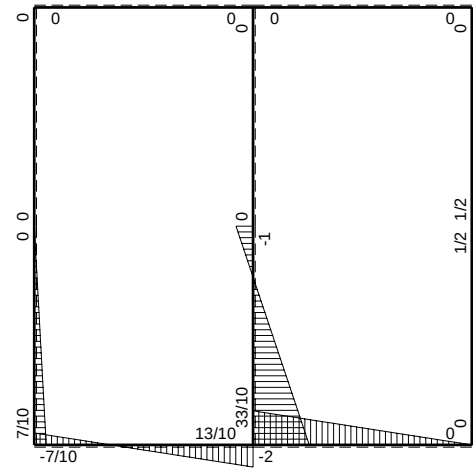
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 155.1 \text{ N/mm}^2$$

$$S = 4407. \text{ mm}^3$$

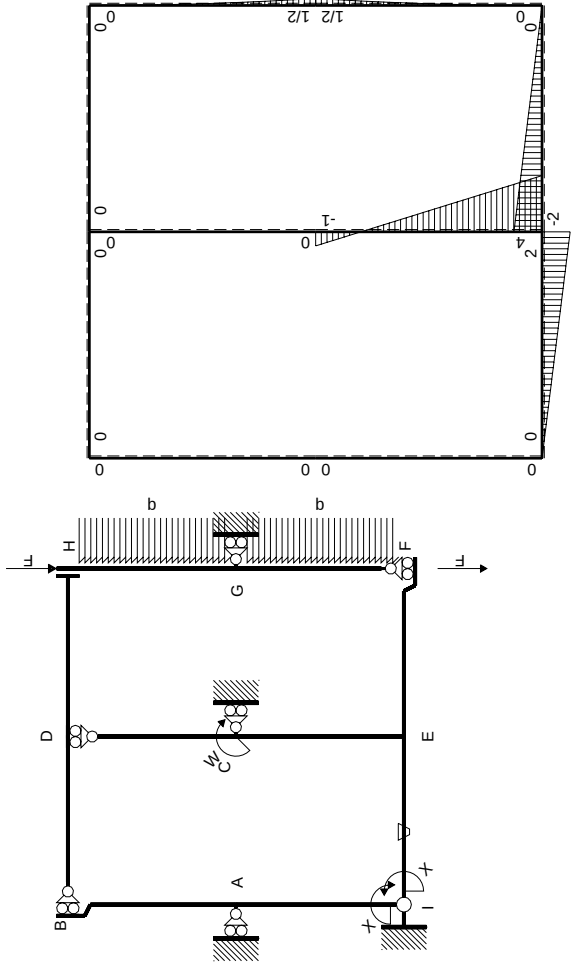


← ⊕ → F

↑ ⊕ ↓ F

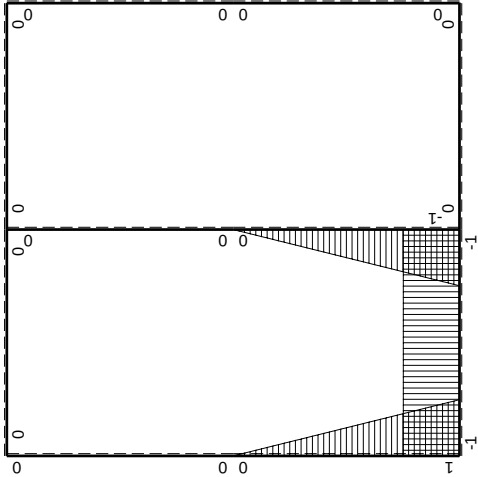


⊕ ⊕ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-5Fx$	0	$-4Fb+9Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-7/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-5Fx$	0	$Fx-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x_0} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x_0} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

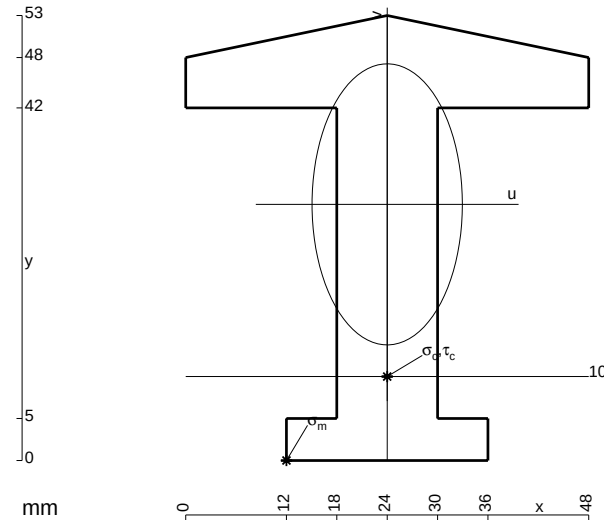
$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x_0} = \int_0^b (-4 + 9x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 9/2 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

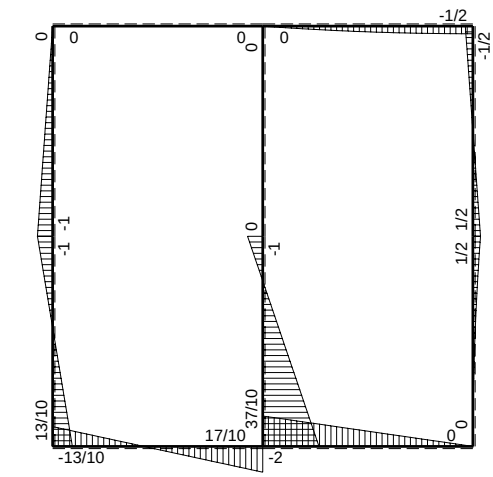
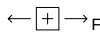
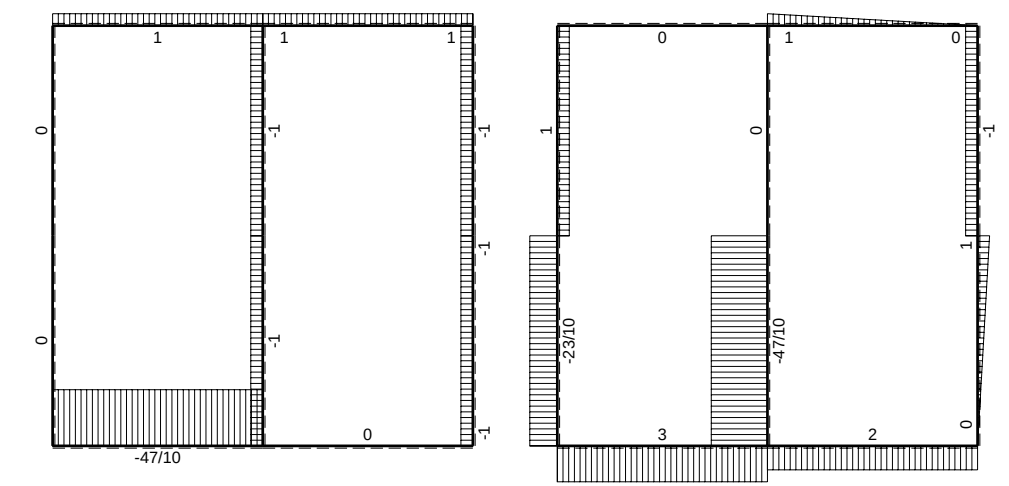
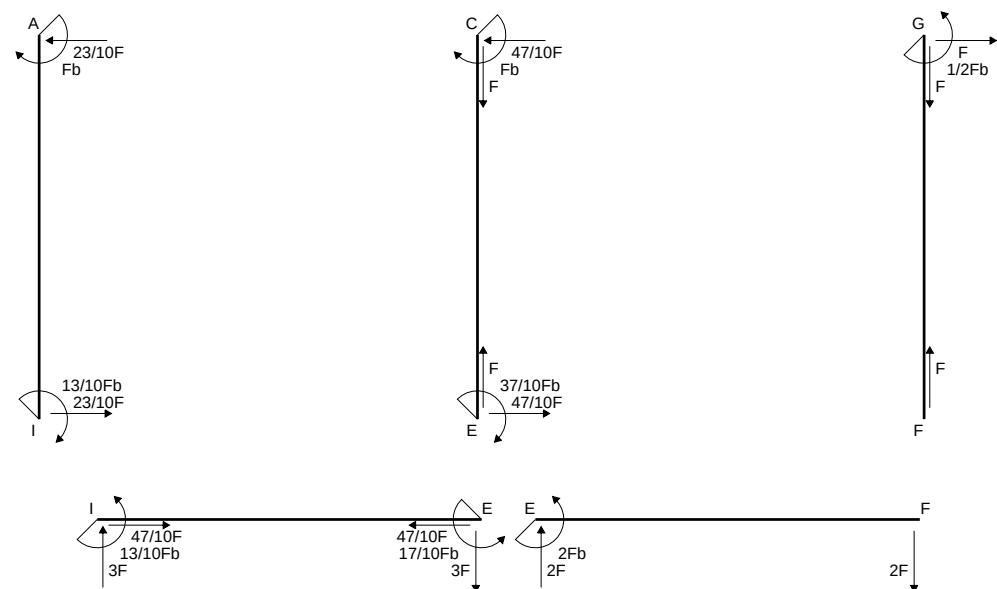
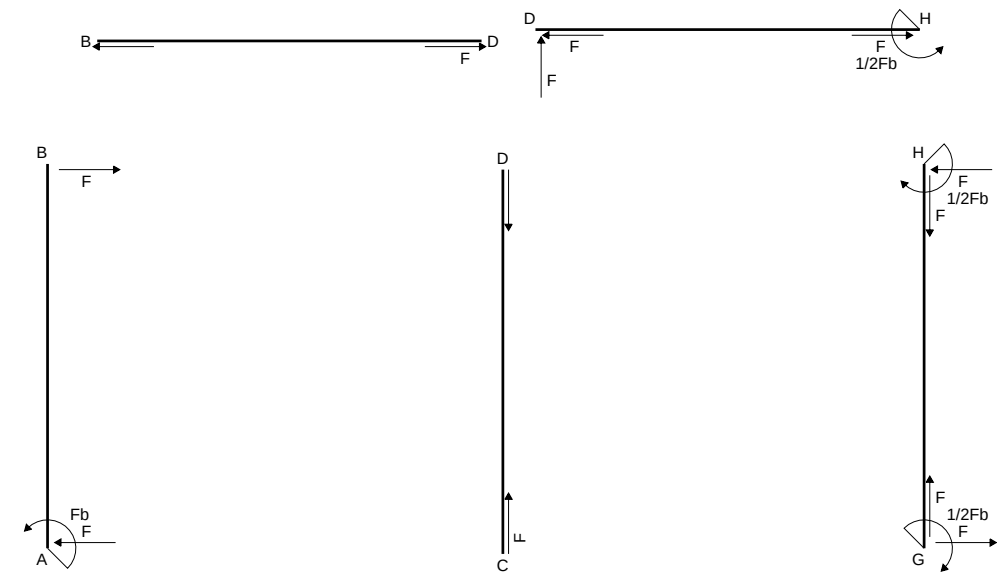
$$= (-4b + 9/2 b - 5/3 b) Fb \frac{1}{EJ} = -7/6 Fb^2/EJ$$

$$L_{CE}^{x_0} = \int_0^b (x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/2 b - 5/3 b) Fb \frac{1}{EJ} = -7/6 Fb^2/EJ$$



$$\begin{aligned} A &= 972. \text{ mm}^2 \\ J_u &= 272405. \text{ mm}^4 \\ J_v &= 77904. \text{ mm}^4 \\ y_g &= 30.51 \text{ mm} \\ T_y &= 3360. \text{ N} \\ M_x &= -1780800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.51 \text{ mm} \\ \sigma_m &= -Mv/J_u = -199.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -20.51 \text{ mm} \\ \sigma_c &= -Mv/J_u = -134.1 \text{ N/mm}^2 \\ \tau_c &= 4.874 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 134.3 \text{ N/mm}^2 \\ S &= 4741. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-6Fx$	0	$-5Fb+11Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$Fb-6Fx$	0	$Fx-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	-Fx	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x0} = \int_0^b (-5 + 11x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 11/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 11/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{x0} = \int_0^b (x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/2 x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

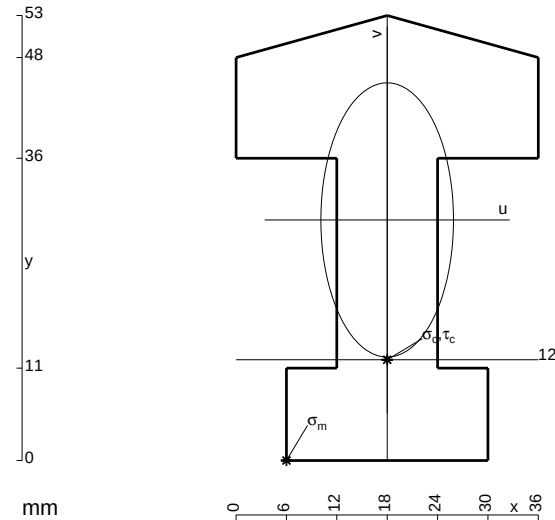
$$= (1/2 b - 2b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{x0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{x0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1086. \text{ mm}^2$$

$$J_u = 289781. \text{ mm}^4$$

$$J_v = 67788. \text{ mm}^4$$

$$y_g = 28.65 \text{ mm}$$

$$T_y = 3660. \text{ N}$$

$$M_x = -2122800. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.65 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209.9 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

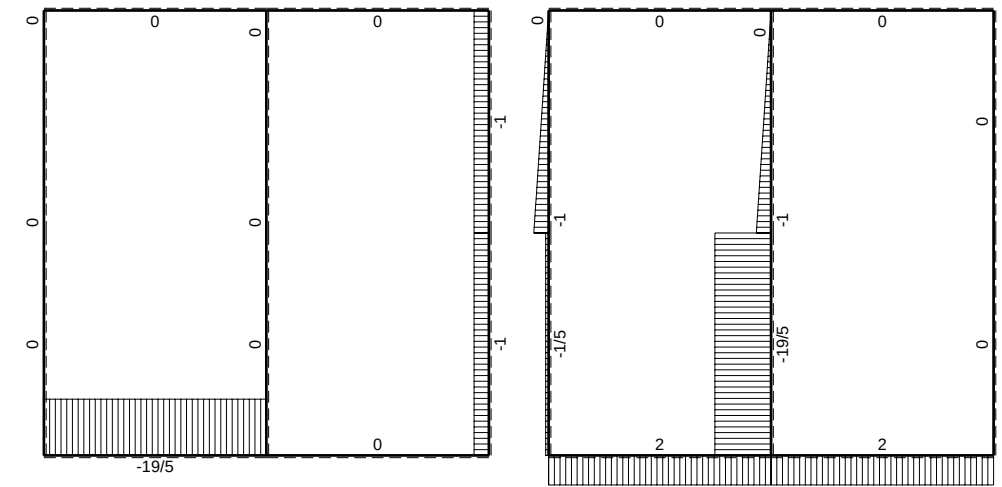
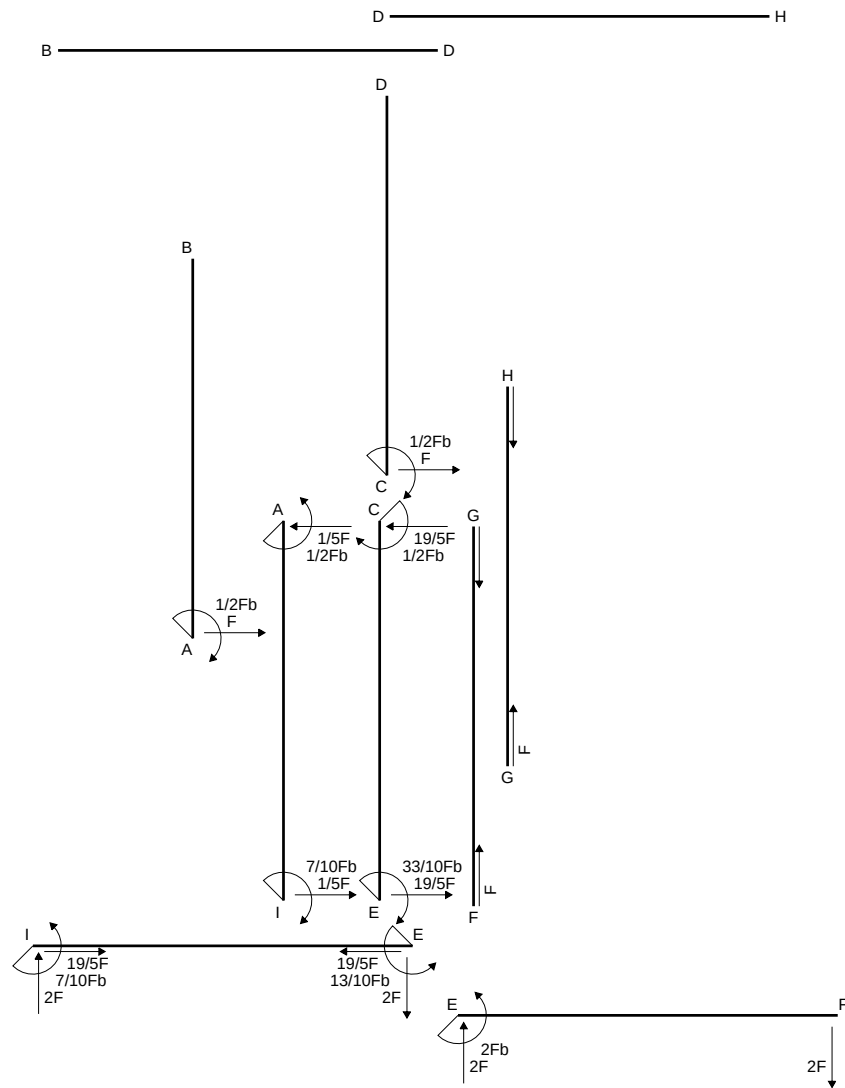
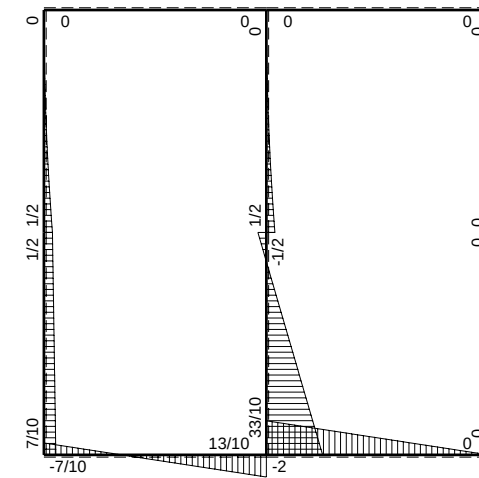
$$v_c = -16.65 \text{ mm}$$

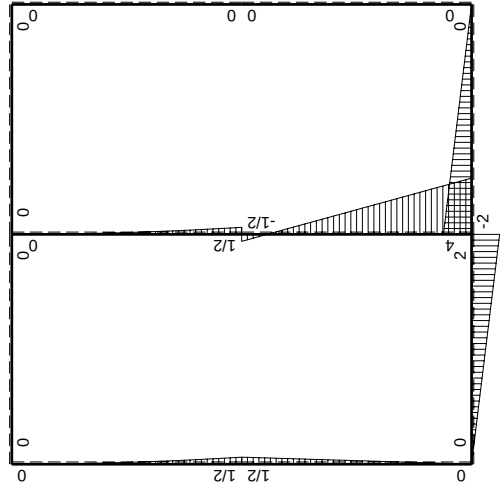
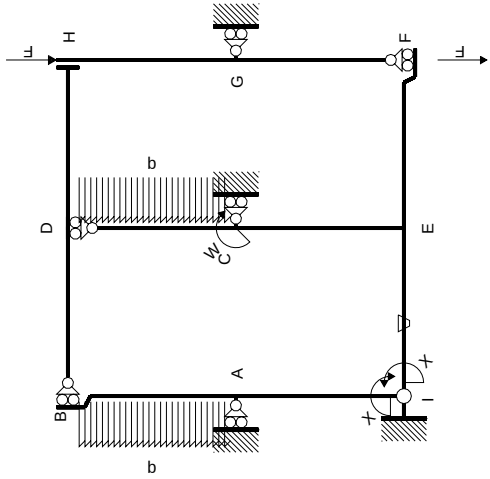
$$\sigma_c = -Mv/J_u = -122. \text{ N/mm}^2$$

$$\tau_c = 6.65 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 122.5 \text{ N/mm}^2$$

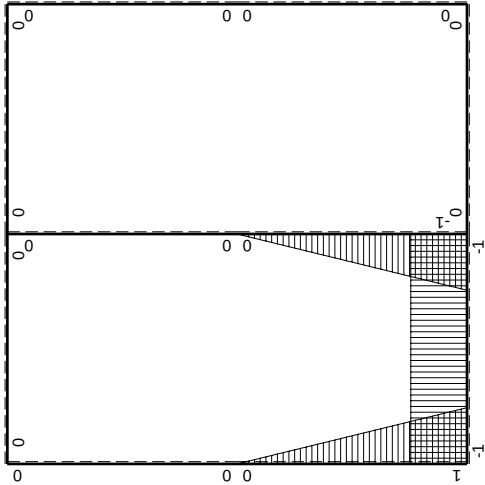
$$S = 6318. \text{ mm}^3$$


$$\leftarrow \boxed{+} \rightarrow F$$




Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2qx^2$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx$	0	$-4Fb+17/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-9/2Fx$	0	$1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{x\theta} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{x\theta} = \int_0^b (-4 + 17/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 17/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

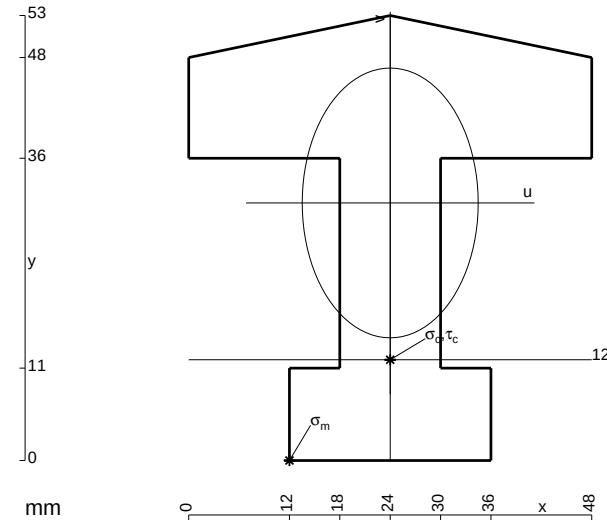
$$= (1/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 1260. \text{ mm}^2$$

$$J_u = 325285. \text{ mm}^4$$

$$J_v = 138384. \text{ mm}^4$$

$$y_g = 30.68 \text{ mm}$$

$$T_y = 3700. \text{ N}$$

$$M_x = -2331000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.68 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -219.8 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

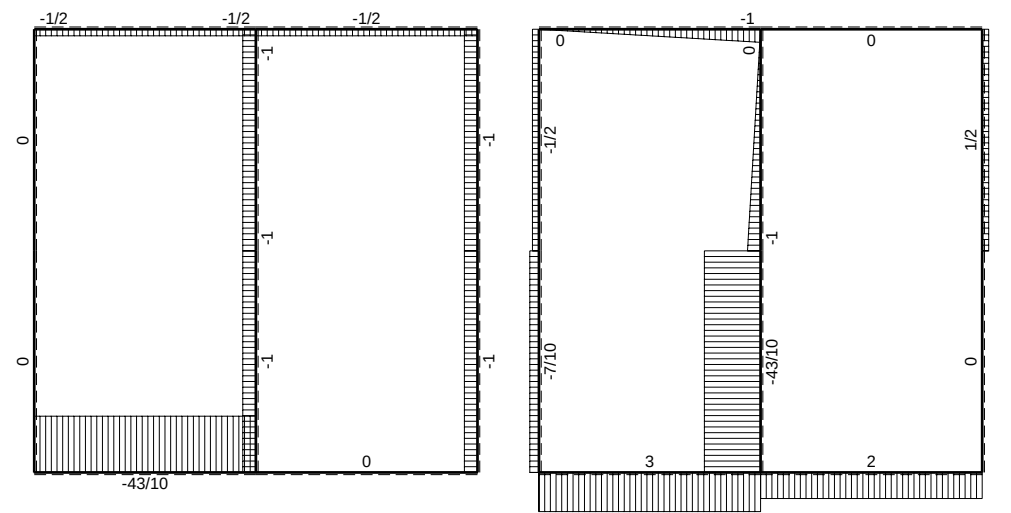
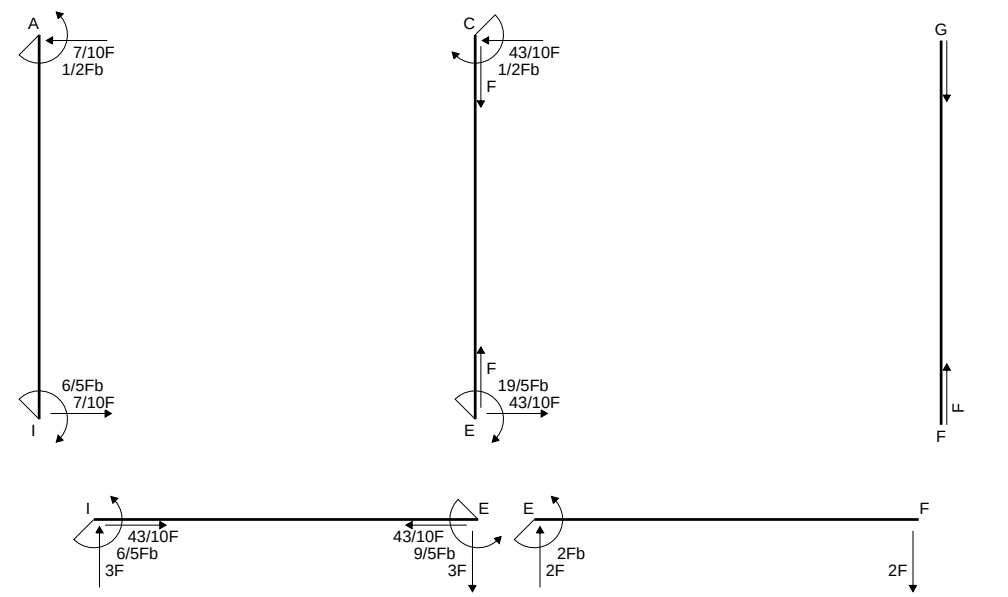
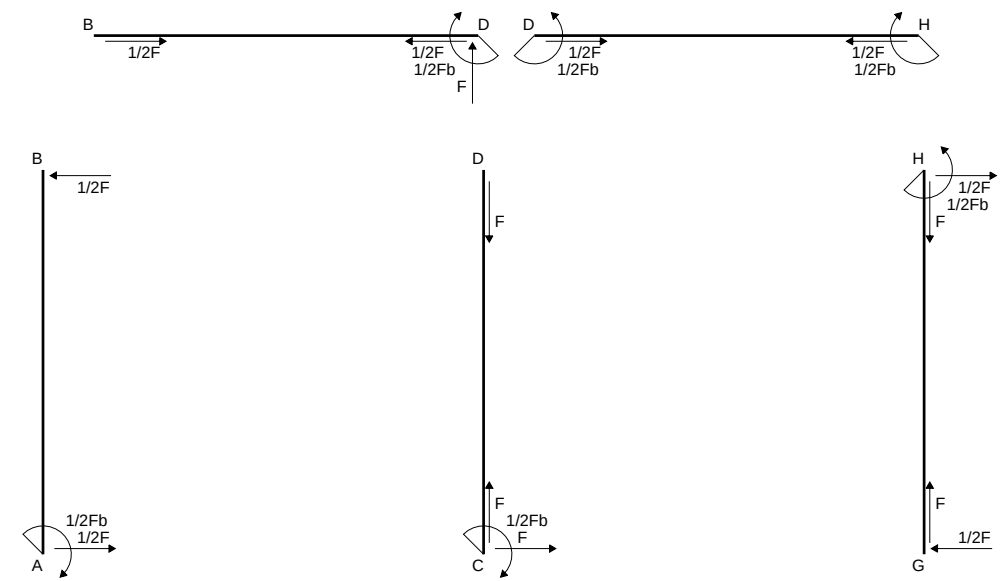
$$v_c = -18.68 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -133.8 \text{ N/mm}^2$$

$$\tau_c = 6.519 \text{ N/mm}^2$$

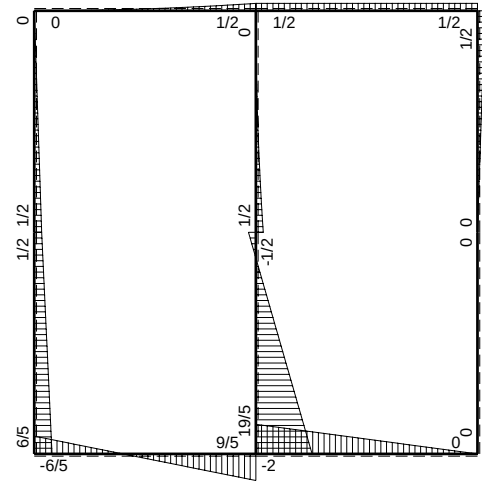
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 134.3 \text{ N/mm}^2$$

$$S = 6877. \text{ mm}^3$$

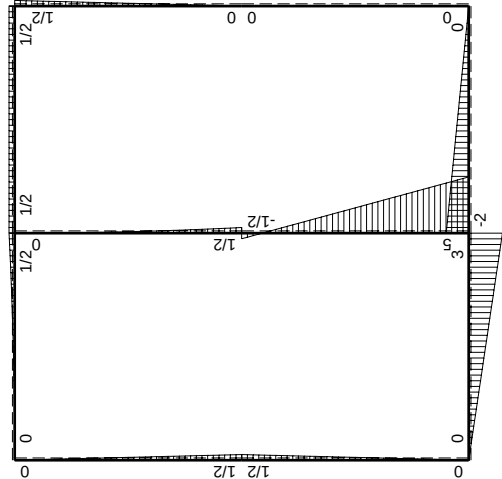
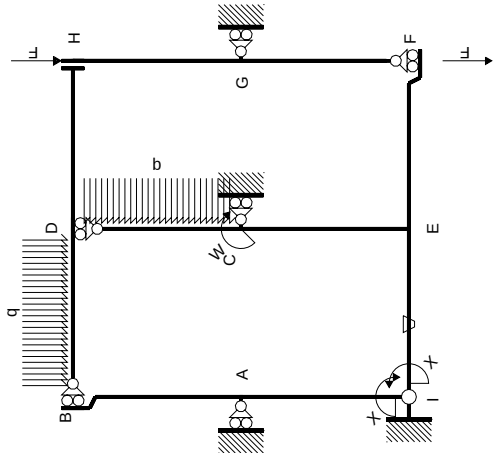


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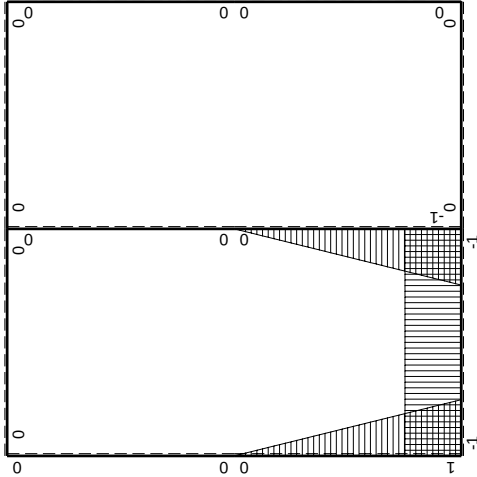


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-11/2Fx$	0	$-5Fb+21/2Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-19/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-11/2Fx$	0	$1/2Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$6/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 21/4 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 21/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

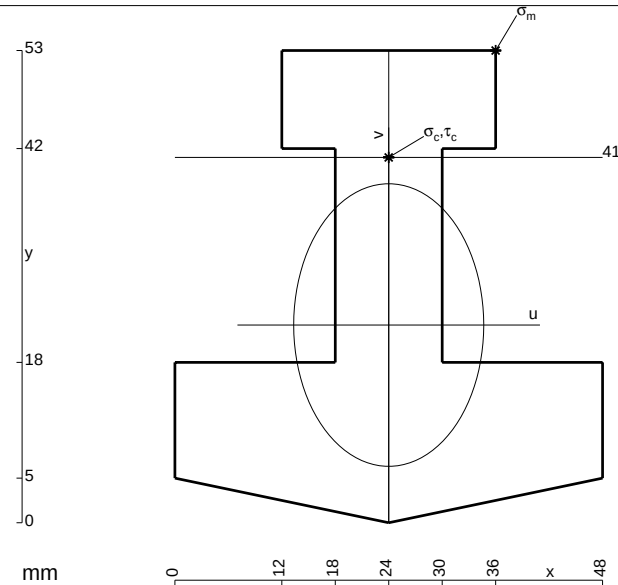
$$= (1/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (1/2 x/b - 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (1/4 b - 1/6 b) Fb \frac{1}{EJ} = 1/12 Fb^2/EJ$$



$$A = 1296. \text{ mm}^2$$

$$J_u = 326102. \text{ mm}^4$$

$$J_v = 147456. \text{ mm}^4$$

$$y_g = 22.19 \text{ mm}$$

$$T_y = 3560. \text{ N}$$

$$M_x = -2420800. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.81 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 228.7 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

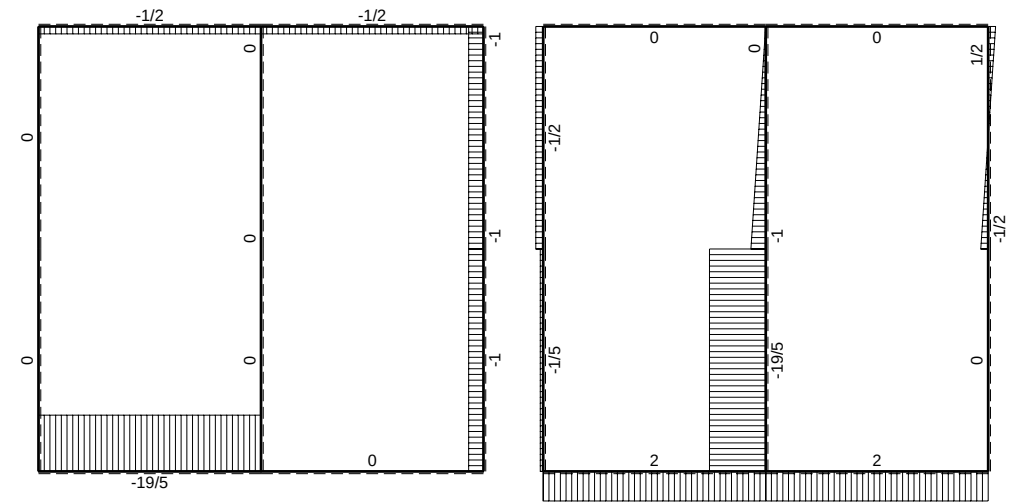
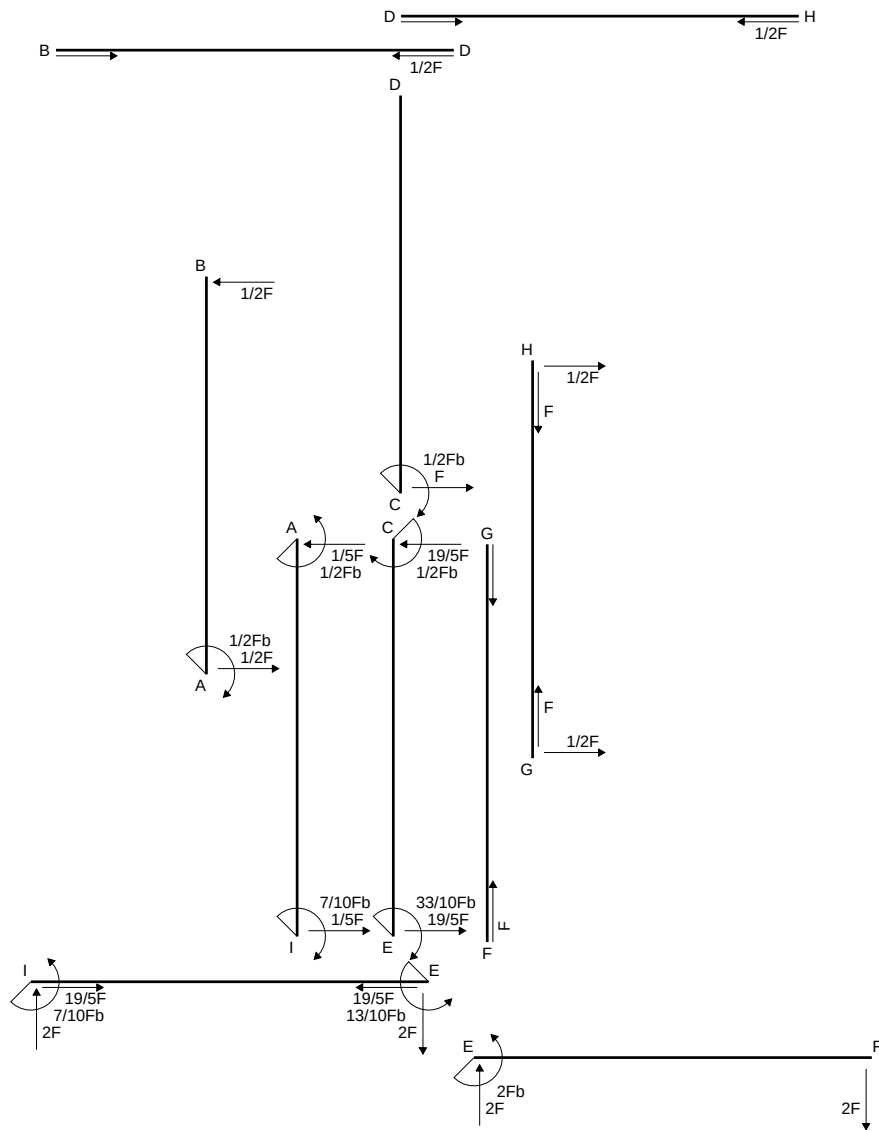
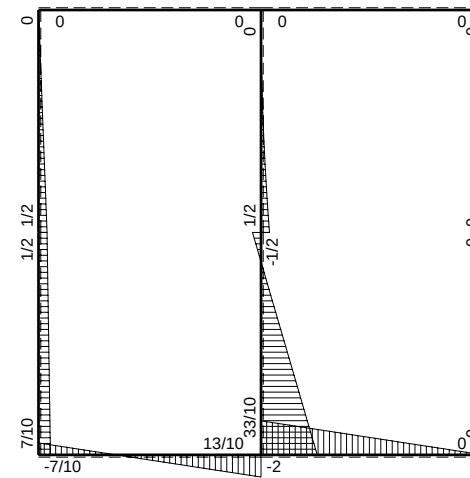
$$v_c = 18.81 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 139.6 \text{ N/mm}^2$$

$$\tau_c = 6.29 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 140.1 \text{ N/mm}^2$$

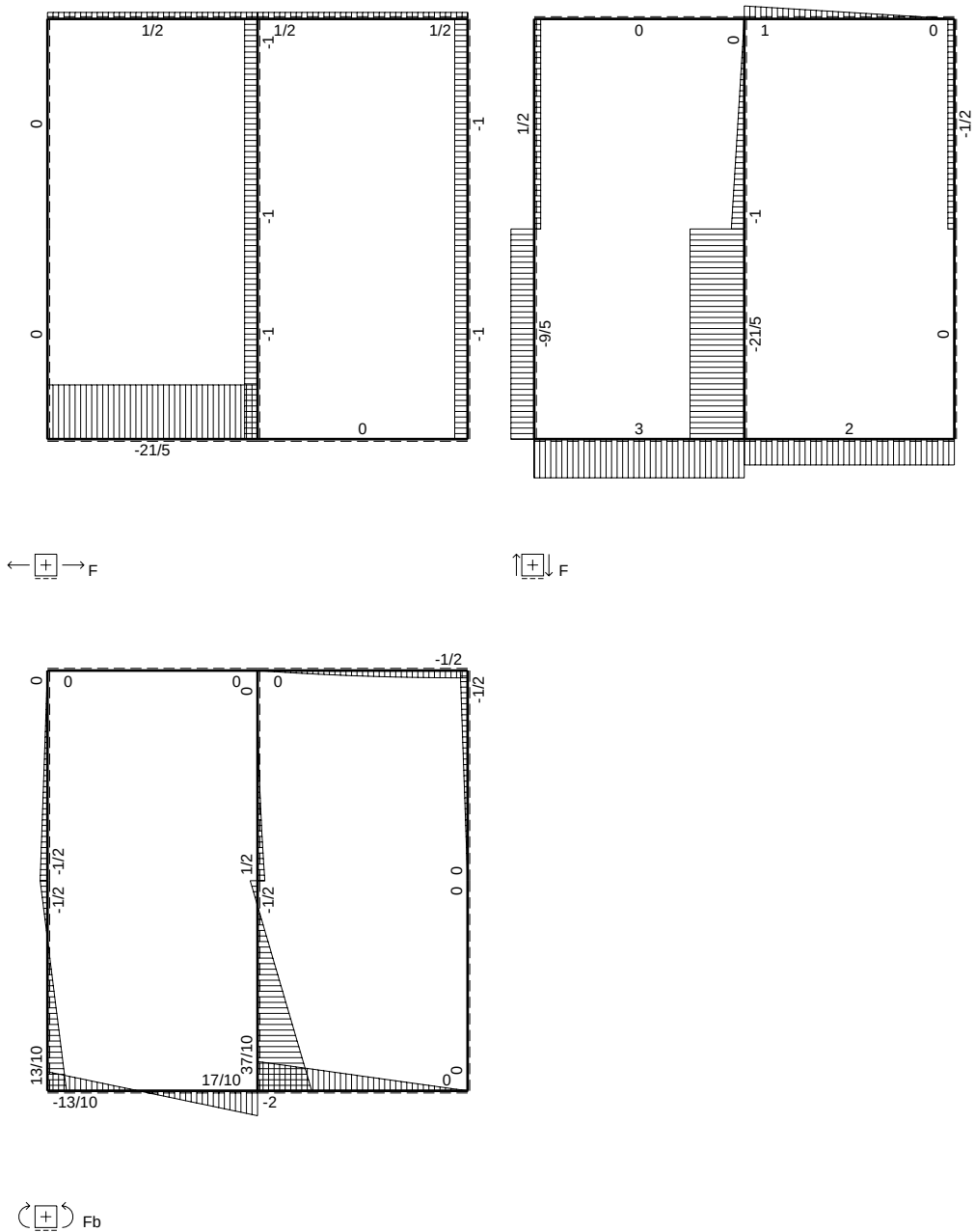
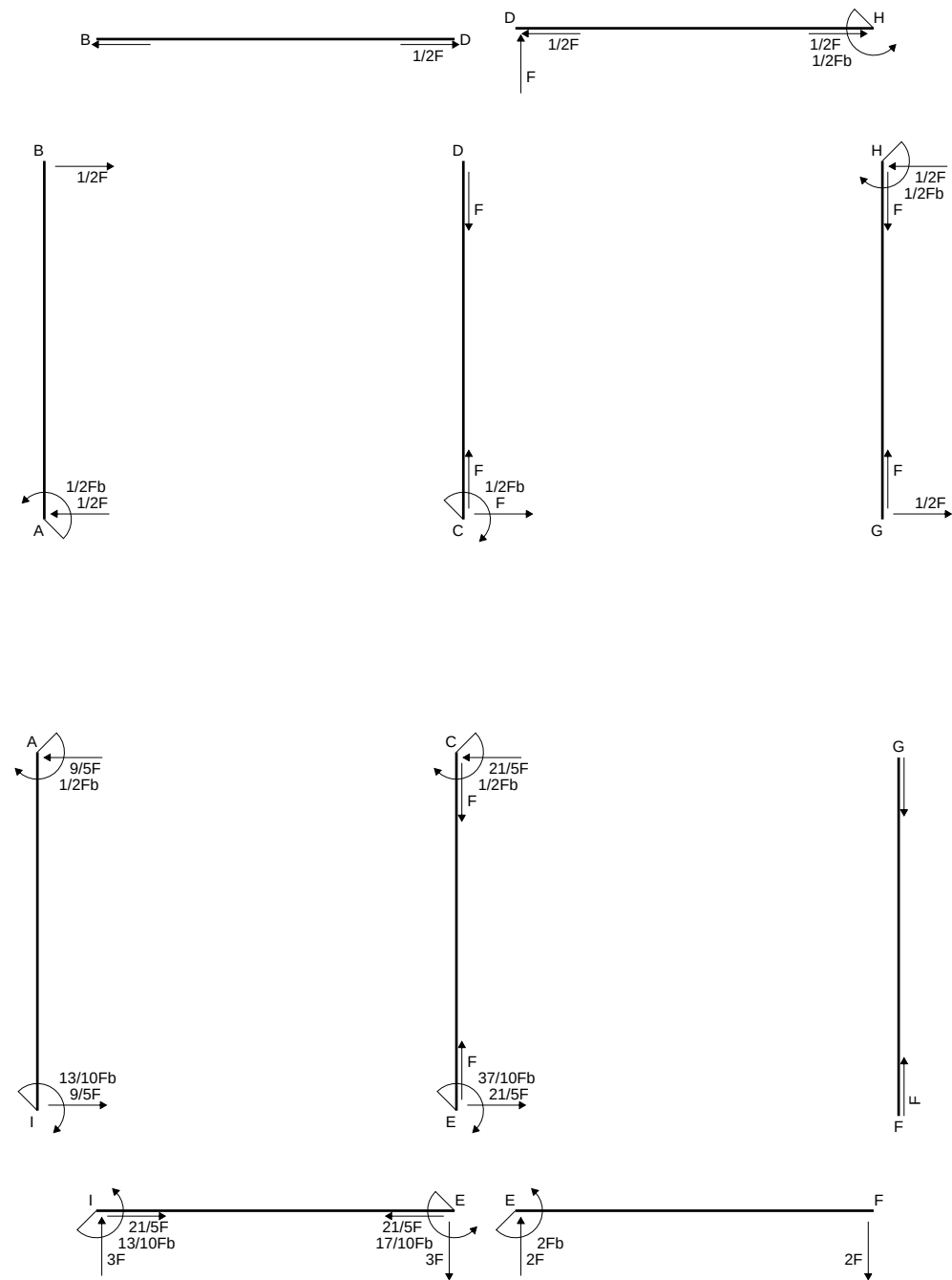
$$S = 6914. \text{ mm}^3$$

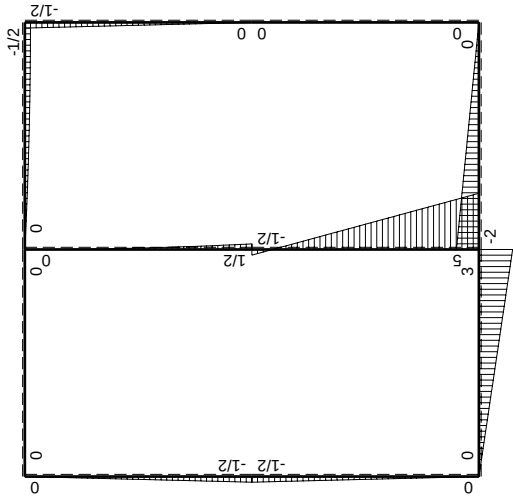
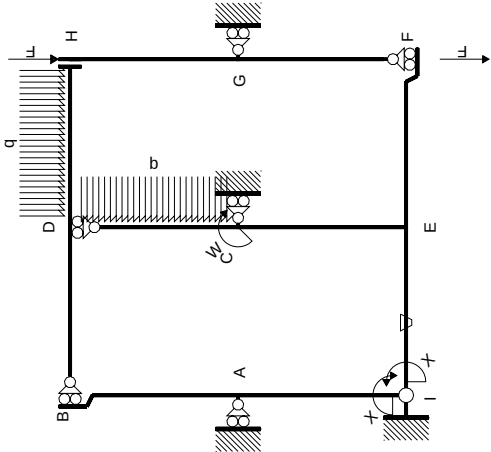

$$\leftarrow \boxed{+} \rightarrow F$$


Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx$	0	$-4Fb+17/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-9/2Fx$	0	$1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$-1/2Fb+1/2Fx$	0	$1/2Fx-1/2Fx^2/b$	0	x^2/b^2		
	totali						$-7/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/10Fb$	

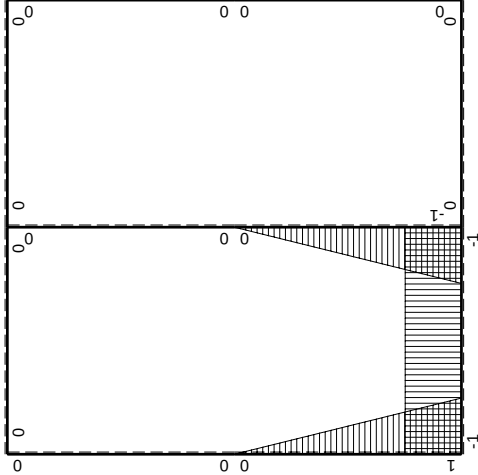
Sviluppi di calcolo iperstatica





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-11/2Fx$	0	$-5Fb+21/2Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-19/12+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-11/2Fx$	0	$1/2Fx-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 21/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 21/4 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 21/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

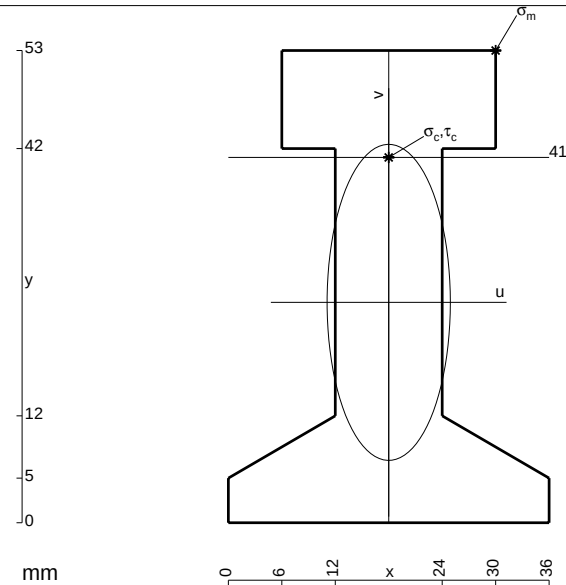
$$= (1/4 b - 11/6 b) Fb \frac{1}{EJ} = -19/12 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 972. \text{ mm}^2$$

$$J_u = 305841. \text{ mm}^4$$

$$J_v = 46512. \text{ mm}^4$$

$$y_g = 24.73 \text{ mm}$$

$$T_y = 2720. \text{ N}$$

$$M_x = -2148800. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.27 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 198.6 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

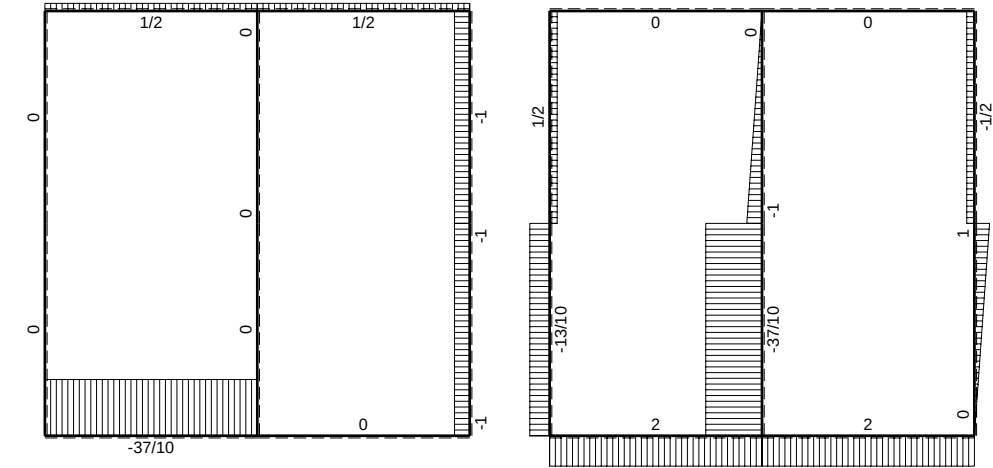
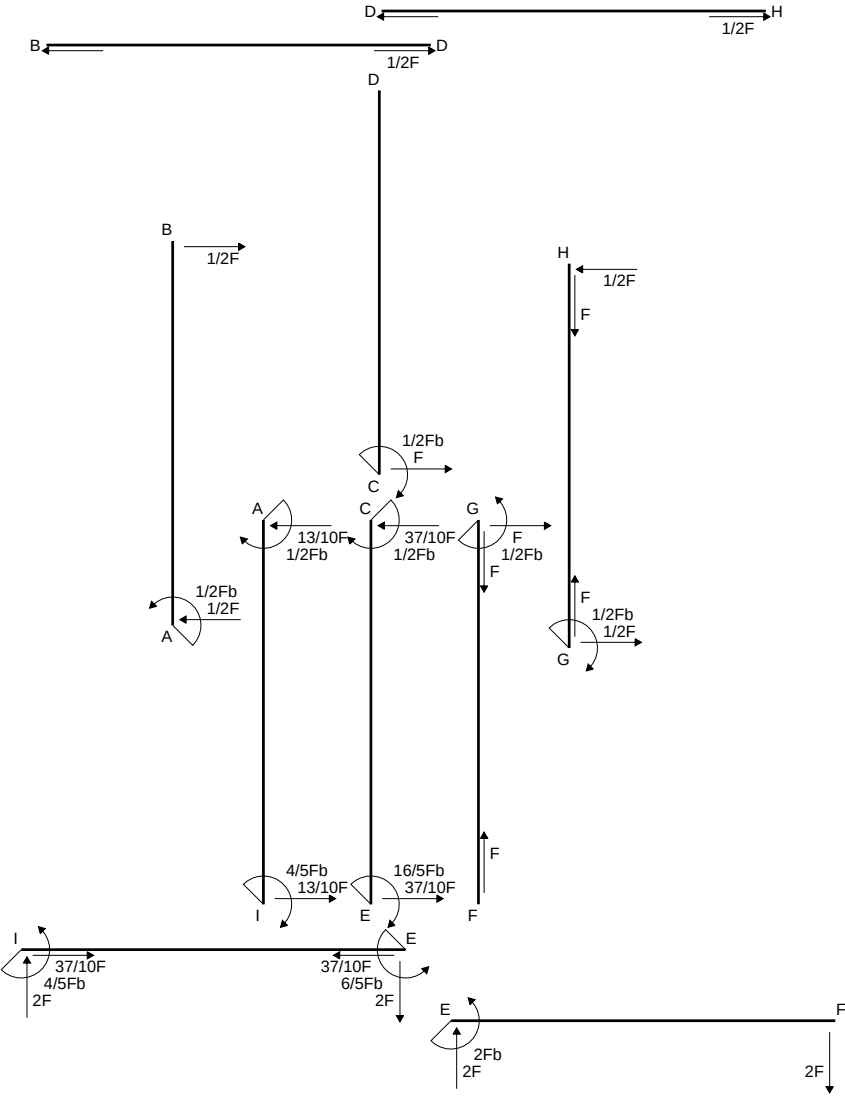
$$v_c = 16.27 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 114.3 \text{ N/mm}^2$$

$$\tau_c = 4.604 \text{ N/mm}^2$$

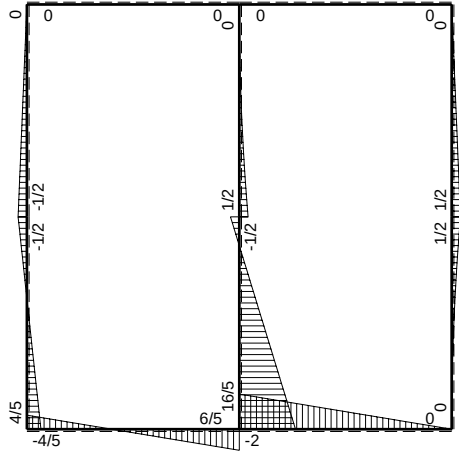
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 114.6 \text{ N/mm}^2$$

$$S = 6212. \text{ mm}^3$$

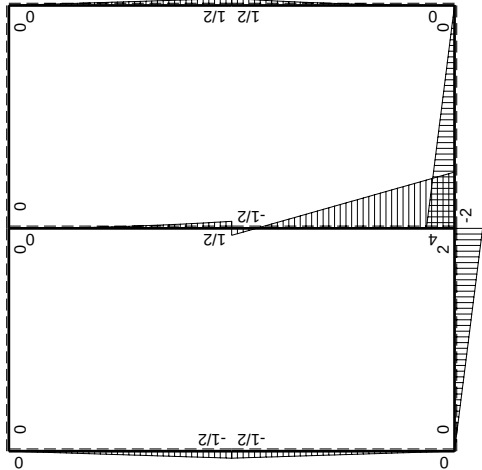
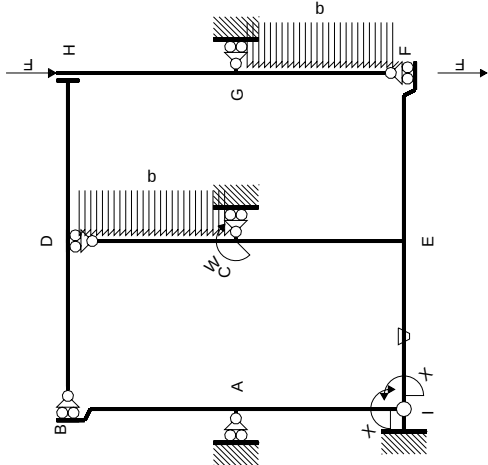


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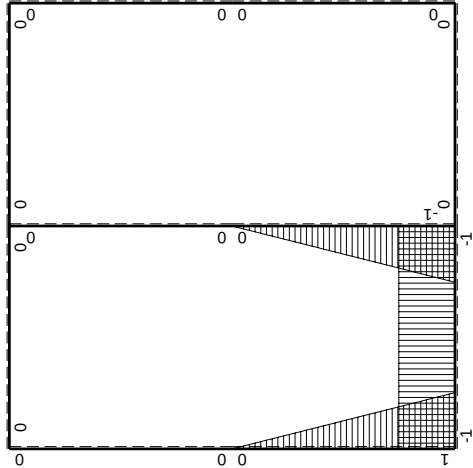


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
DC b	0	$-1/2qx^2$	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-9/2Fx$	0	$-4Fb+17/2Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/4+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$1/2Fb-9/2Fx$	0	$1/2Fx-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-4/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$4/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 17/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 17/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 17/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (1/2 x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[1/4 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

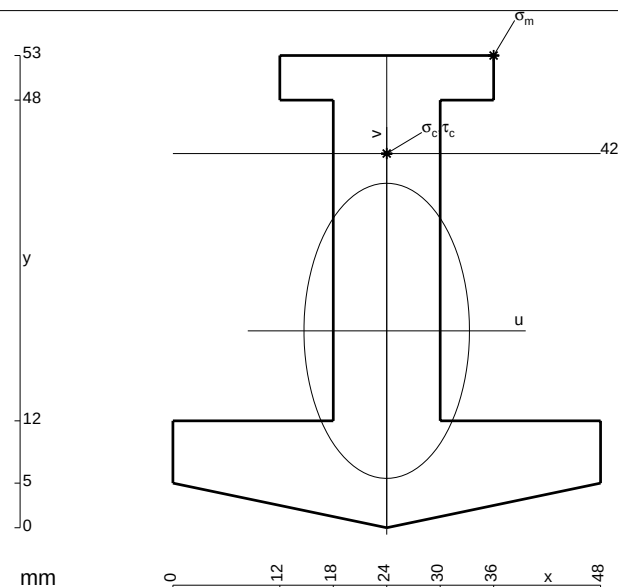
$$= (1/4 b - 3/2 b) Fb \frac{1}{EJ} = -5/4 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

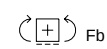
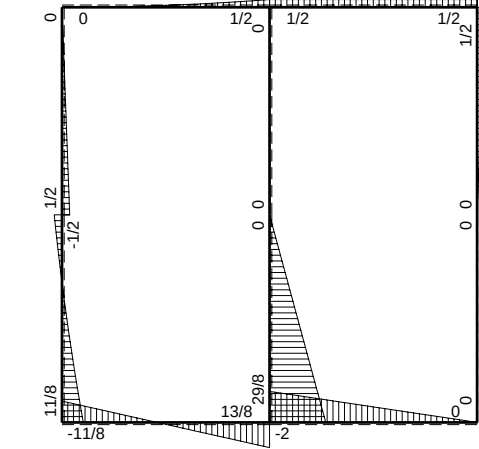
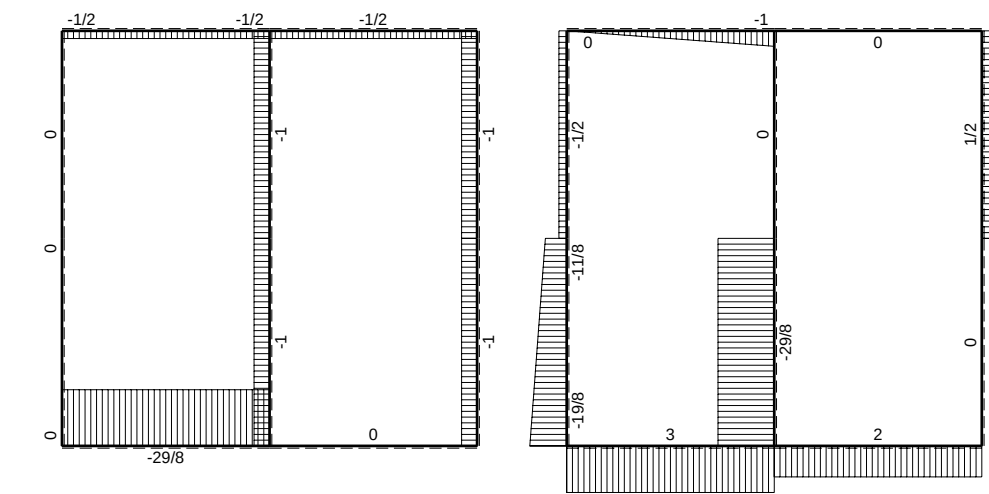
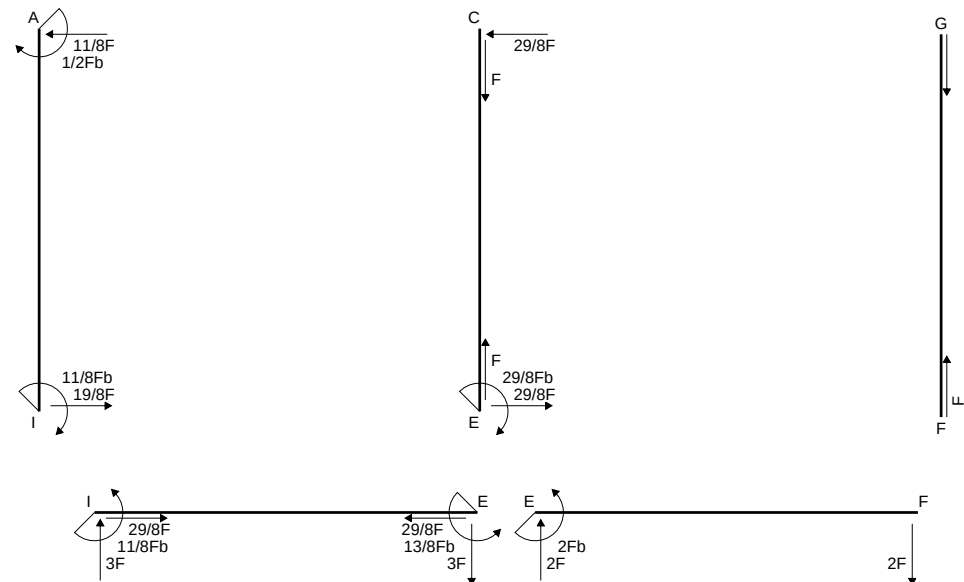
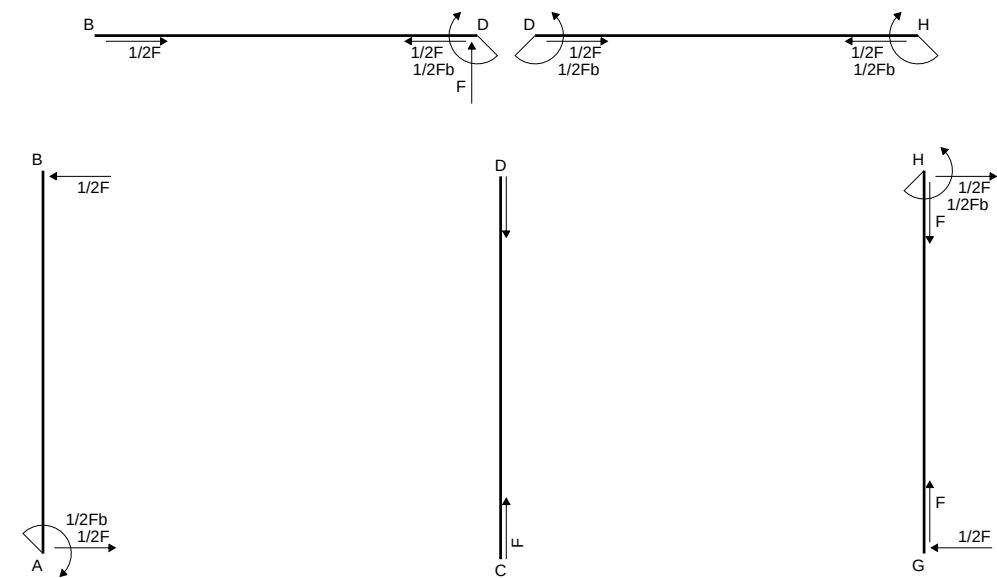
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

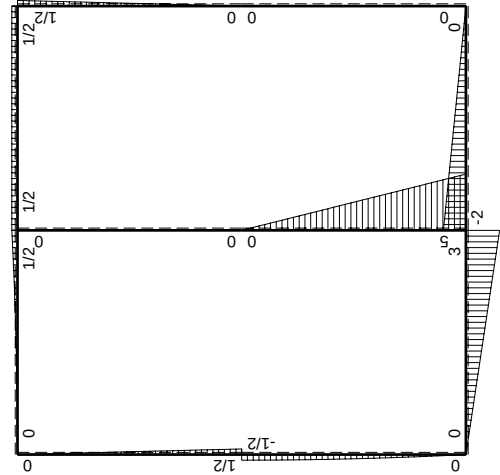
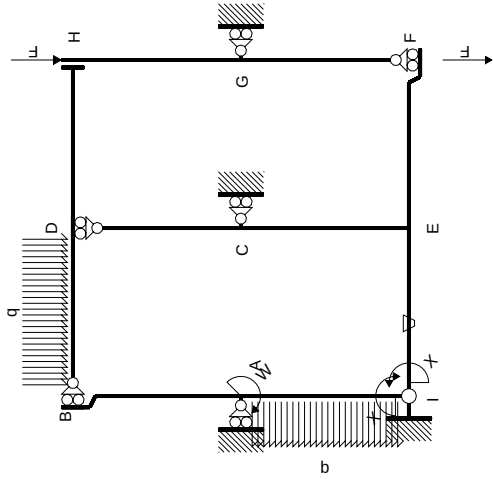
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



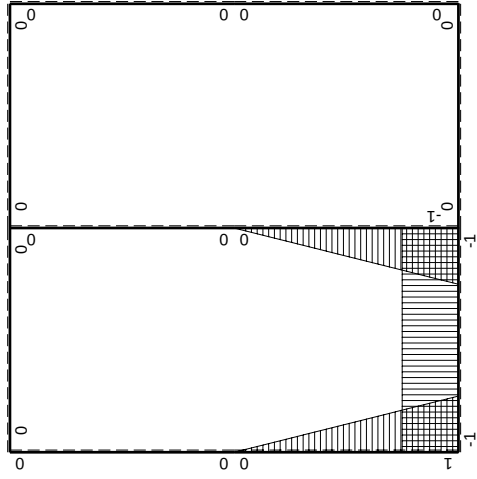
$$\begin{aligned} A &= 1008. \text{ mm}^2 \\ J_u &= 276602. \text{ mm}^4 \\ J_v &= 86976. \text{ mm}^4 \\ y_g &= 22.1 \text{ mm} \\ T_y &= 2220. \text{ N} \\ M_x &= -1864800. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.9 \text{ mm} \\ \sigma_m &= -Mv/J_u = 208.3 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 42. \text{ mm} \\ v_c &= 19.9 \text{ mm} \\ \sigma_c &= -Mv/J_u = 134.2 \text{ N/mm}^2 \\ \tau_c &= 3.382 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 134.3 \text{ N/mm}^2 \\ S &= 5057. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fx+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

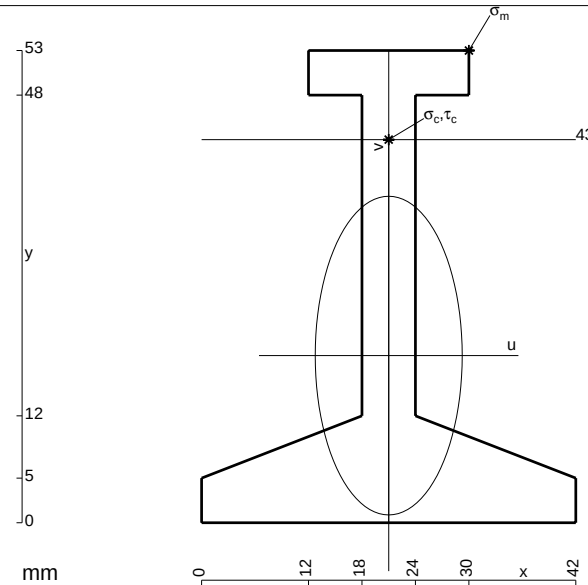
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



$$A = 684. \text{ mm}^2$$

$$J_u = 218819. \text{ mm}^4$$

$$J_v = 46548. \text{ mm}^4$$

$$y_g = 18.76 \text{ mm}$$

$$T_y = 1560. \text{ N}$$

$$M_x = -1404000. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 34.24 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 219.7 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 43. \text{ mm}$$

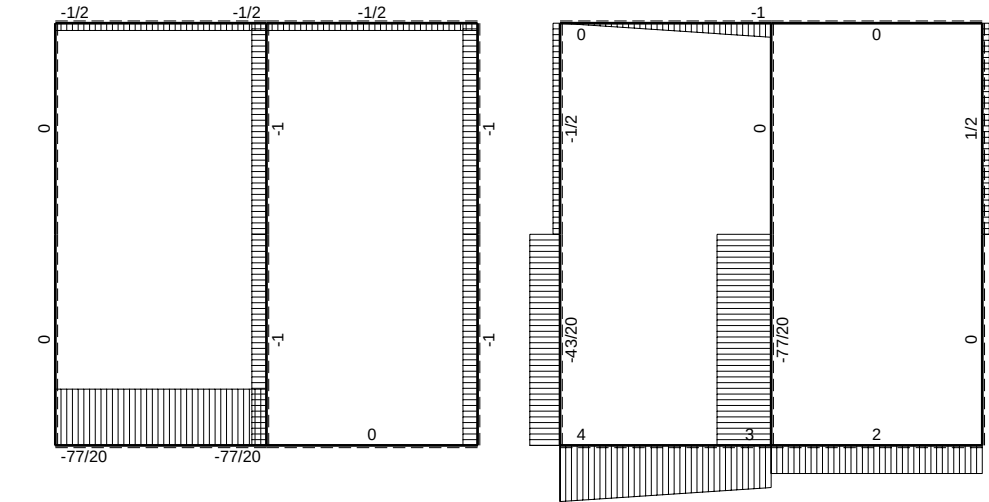
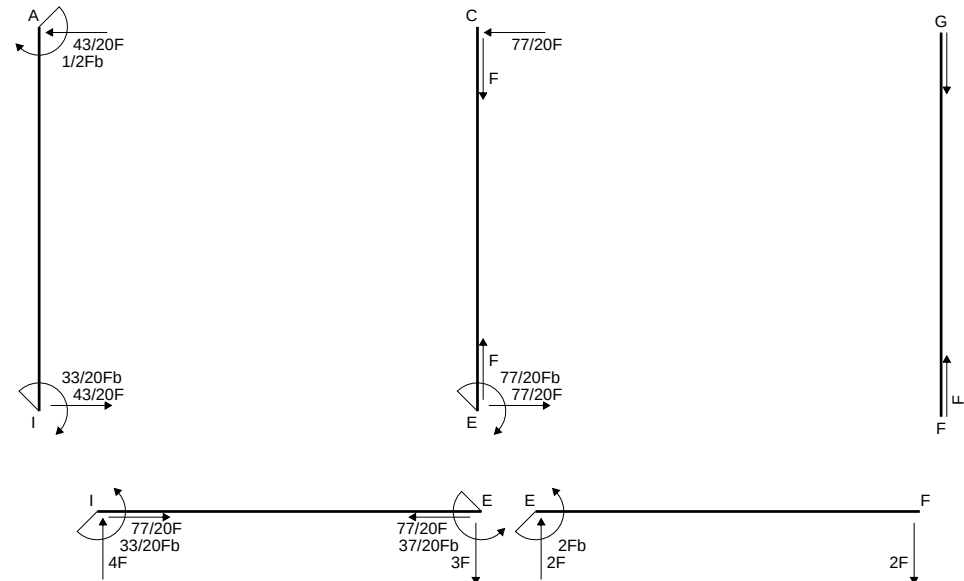
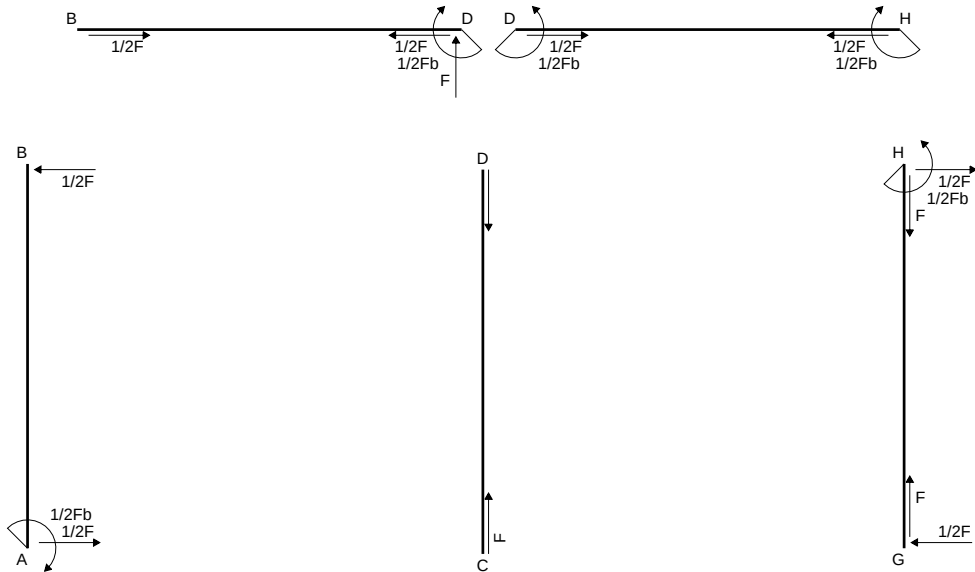
$$v_c = 24.24 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 155.5 \text{ N/mm}^2$$

$$\tau_c = 4.348 \text{ N/mm}^2$$

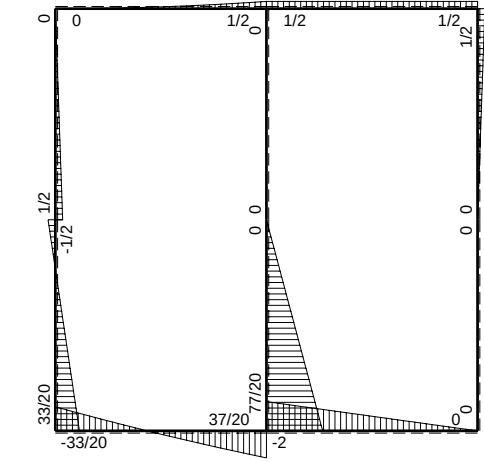
$$\sigma_o = \sqrt{\sigma_c^2 + 3\tau_c^2} = 155.7 \text{ N/mm}^2$$

$$S = 3659. \text{ mm}^3$$

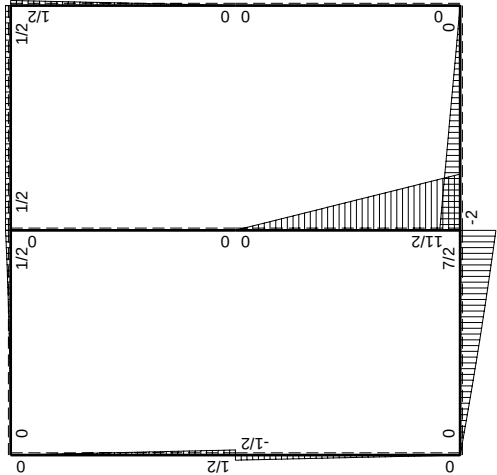
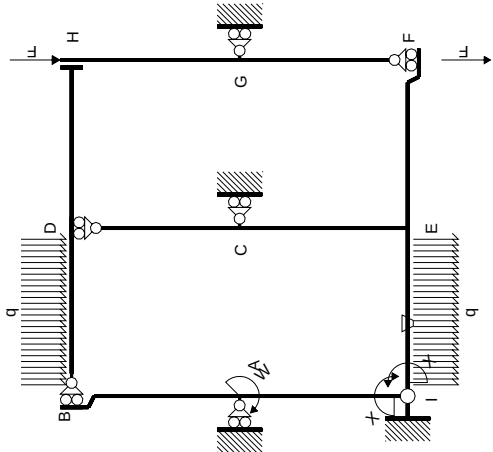


← ⊕ → F

↑ ⊕ ↓ F

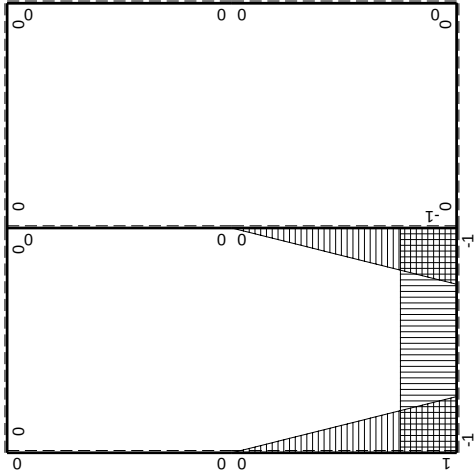


⊕ ⊖ Fb



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

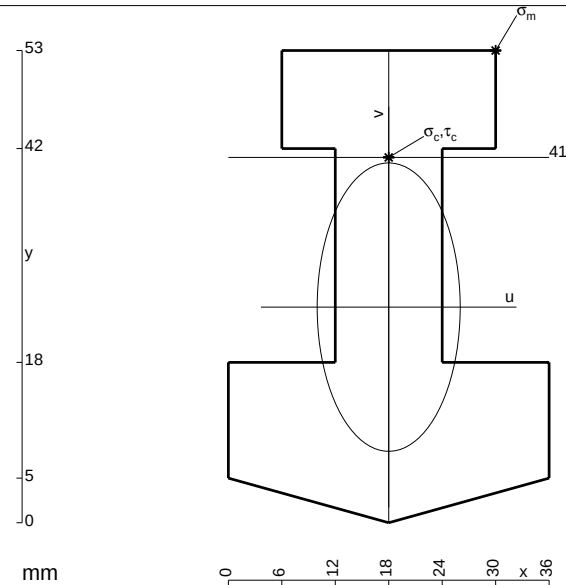
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

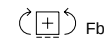
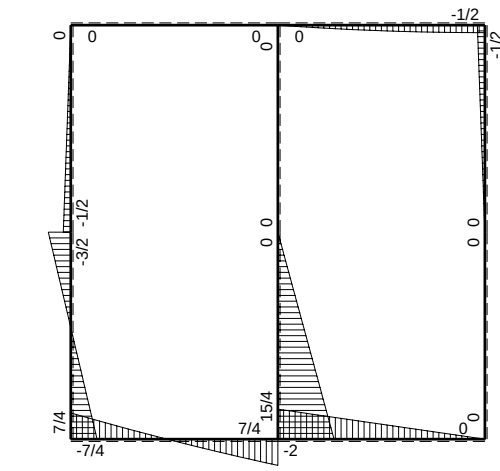
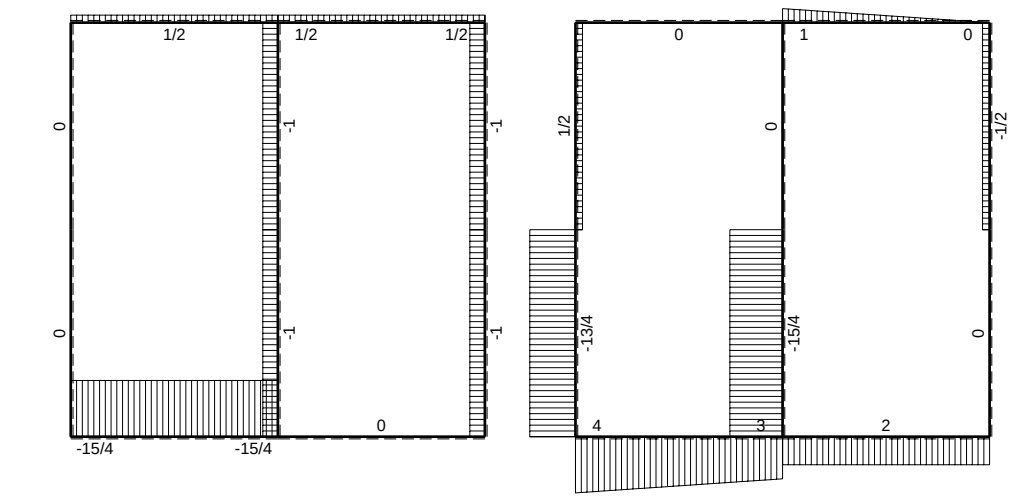
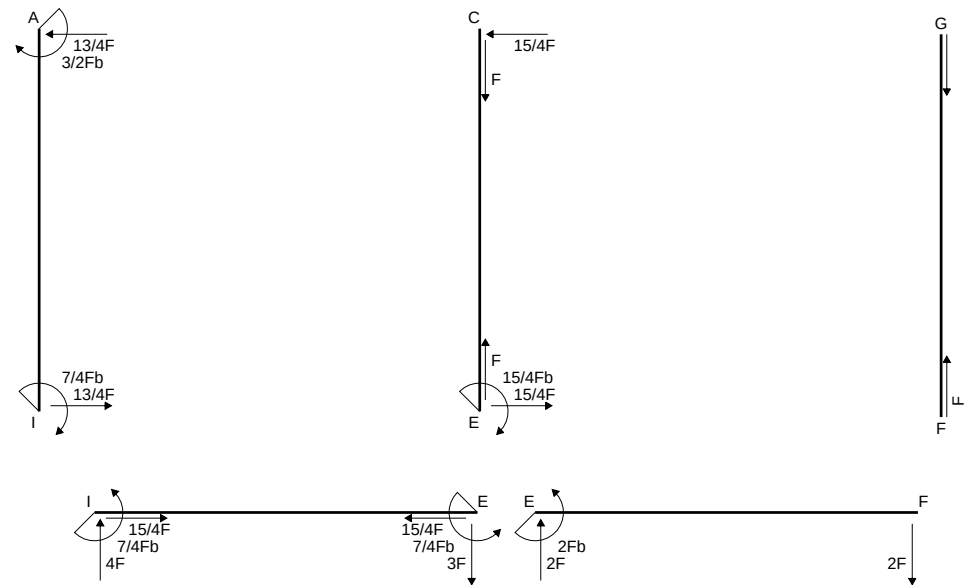
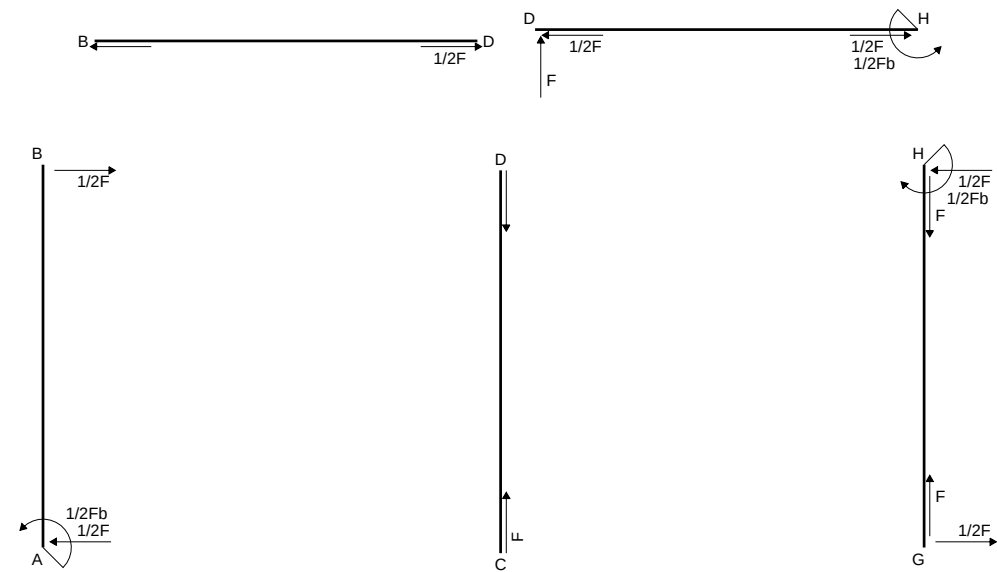
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

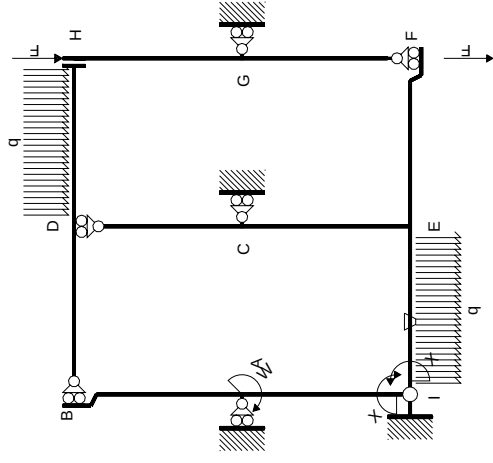
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

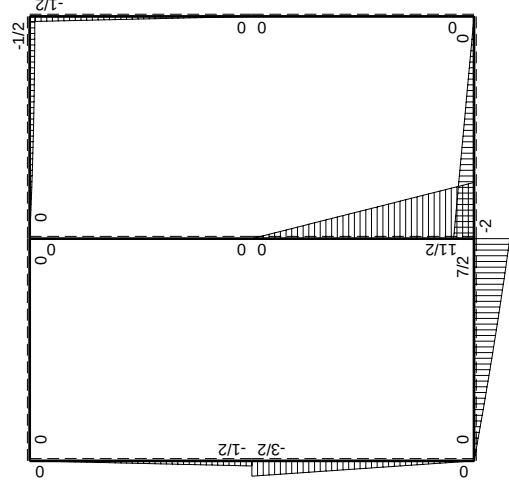
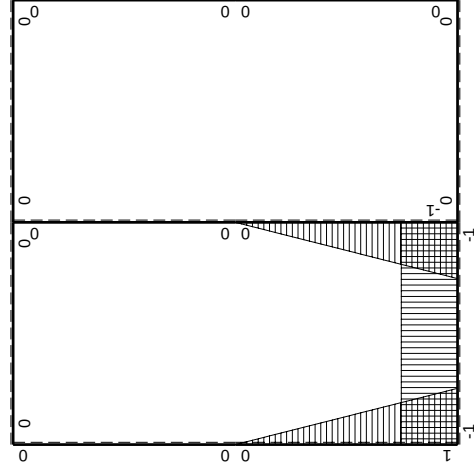


$$\begin{aligned} A &= 1110. \text{ mm}^2 \\ J_u &= 290885. \text{ mm}^4 \\ J_v &= 71532. \text{ mm}^4 \\ y_g &= 24.2 \text{ mm} \\ T_y &= 2440. \text{ N} \\ M_x &= -2318000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 53. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.8 \text{ mm} \\ \sigma_m &= -Mv/J_u = 229.5 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 41. \text{ mm} \\ v_c &= 16.8 \text{ mm} \\ \sigma_c &= -Mv/J_u = 133.9 \text{ N/mm}^2 \\ \tau_c &= 4.445 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 134.1 \text{ N/mm}^2 \\ S &= 6359. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

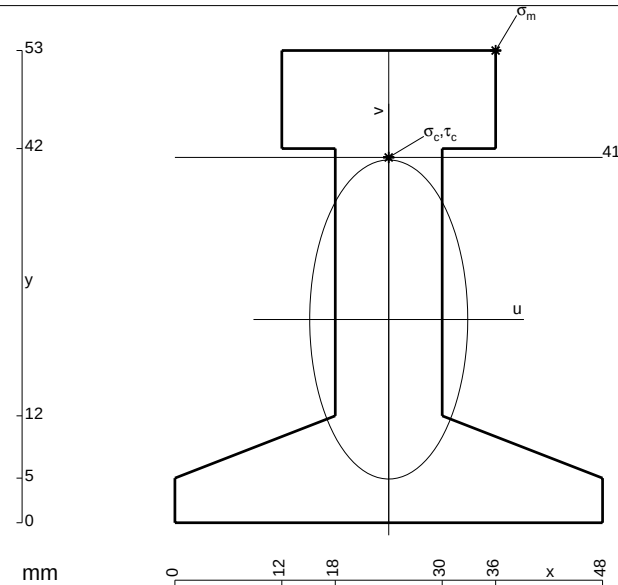
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 1074. \text{ mm}^2$$

$$J_u = 344482. \text{ mm}^4$$

$$J_v = 84492. \text{ mm}^4$$

$$y_g = 22.81 \text{ mm}$$

$$T_y = 2720. \text{ N}$$

$$M_x = -2720000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.19 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.4 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 41. \text{ mm}$$

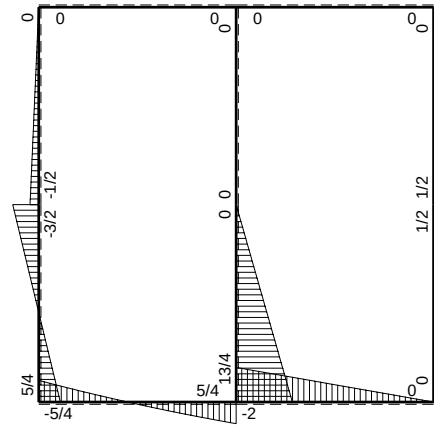
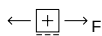
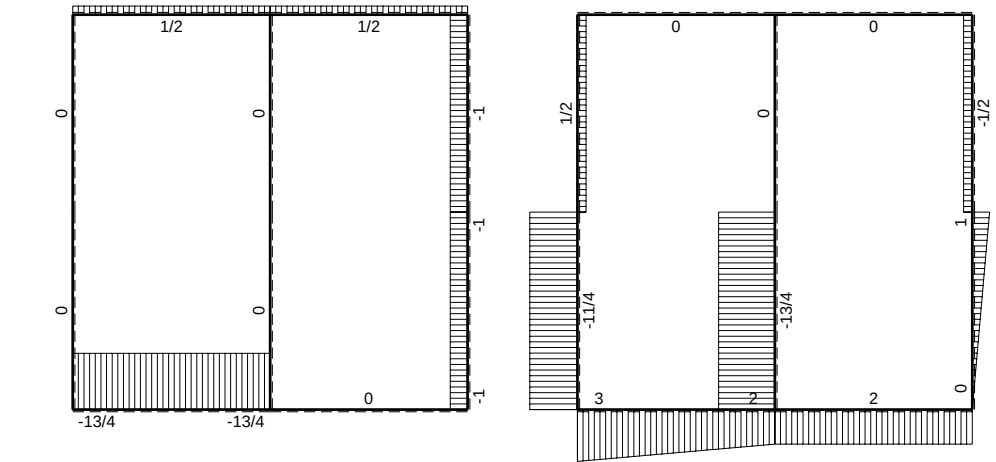
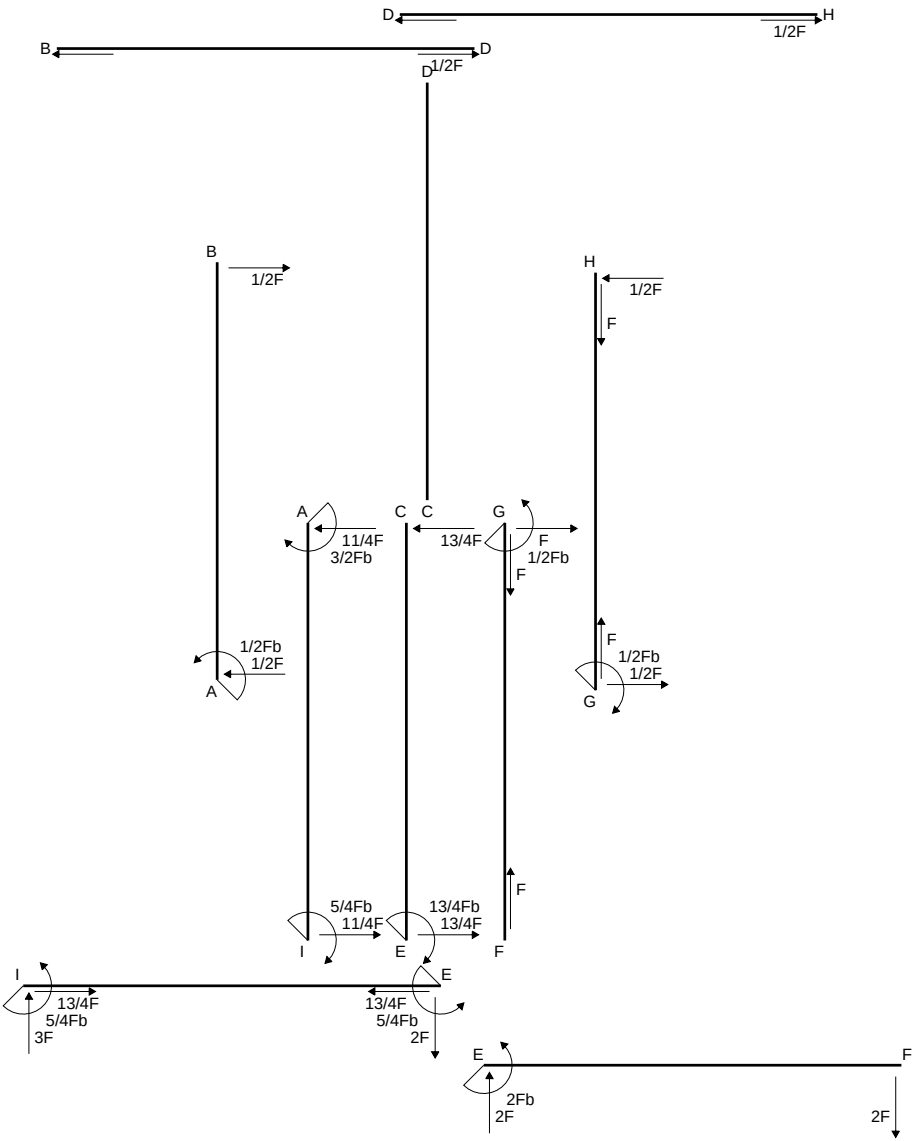
$$v_c = 18.19 \text{ mm}$$

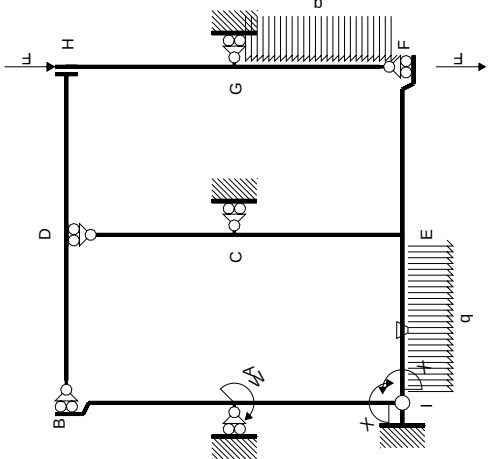
$$\sigma_c = -Mv/J_u = 143.6 \text{ N/mm}^2$$

$$\tau_c = 4.436 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 143.8 \text{ N/mm}^2$$

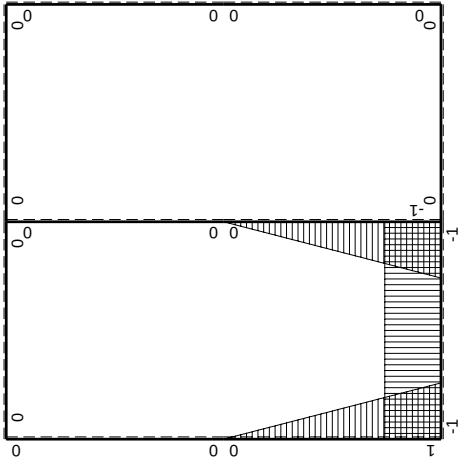
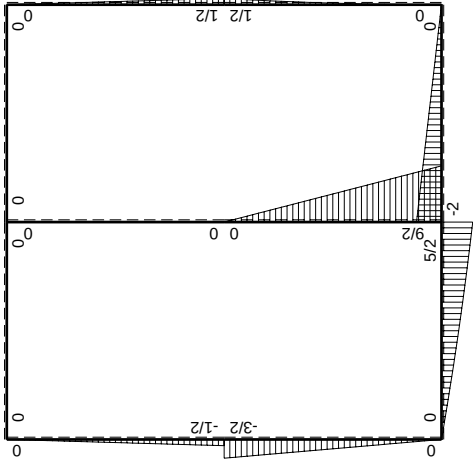
$$S = 6742. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

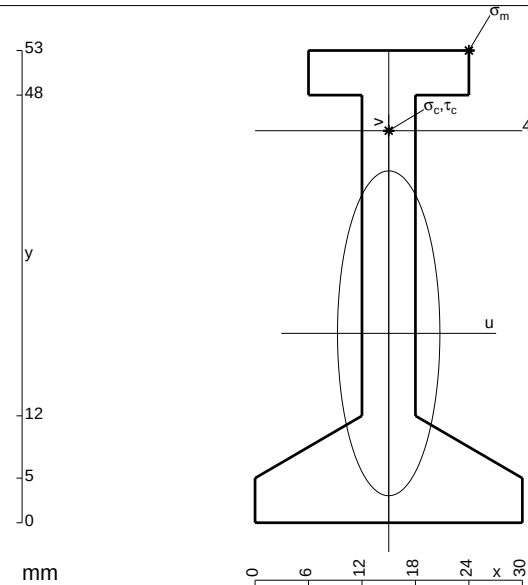
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 582. \text{ mm}^2$$

$$J_u = 193597. \text{ mm}^4$$

$$J_v = 19242. \text{ mm}^4$$

$$y_g = 21.26 \text{ mm}$$

$$T_y = 2300. \text{ N}$$

$$M_x = -1219000. \text{ Nmm}$$

$$x_m = 24. \text{ mm}$$

$$y_m = 53. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 31.74 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 199.9 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 44. \text{ mm}$$

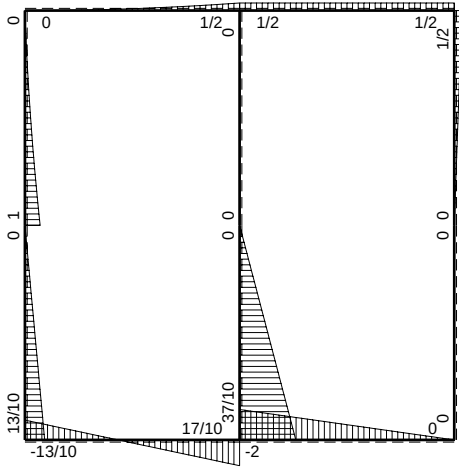
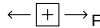
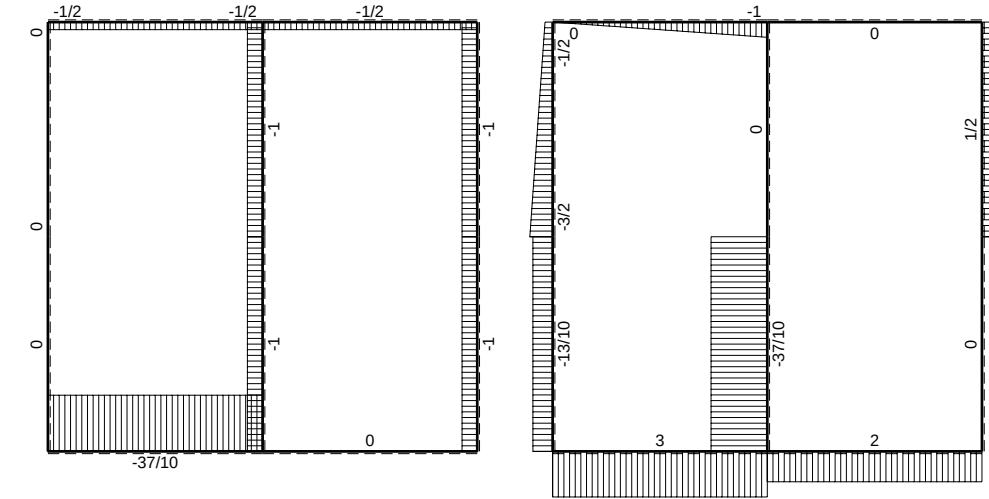
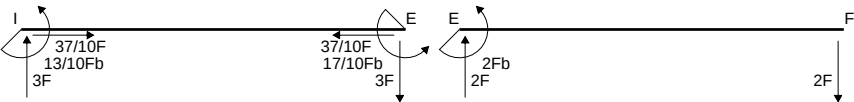
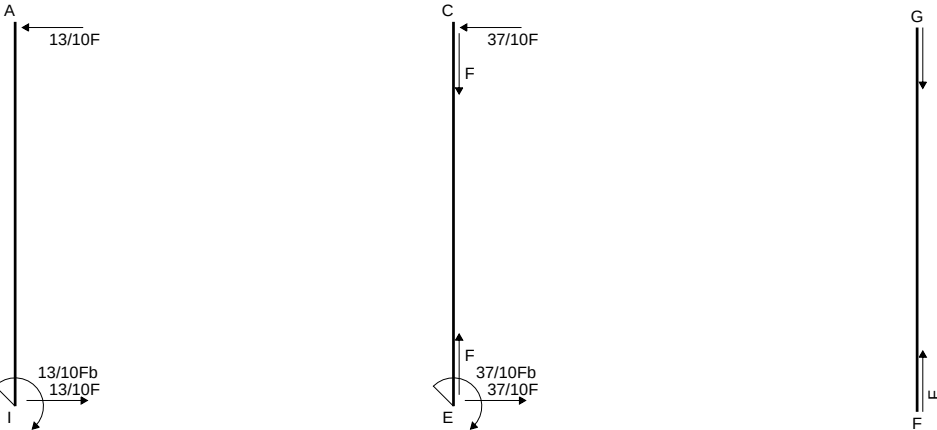
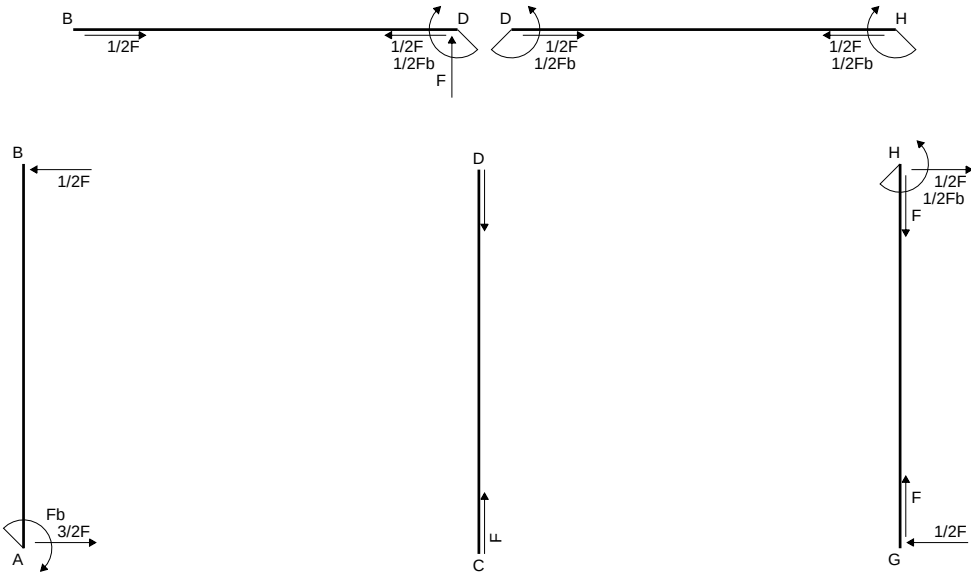
$$v_c = 22.74 \text{ mm}$$

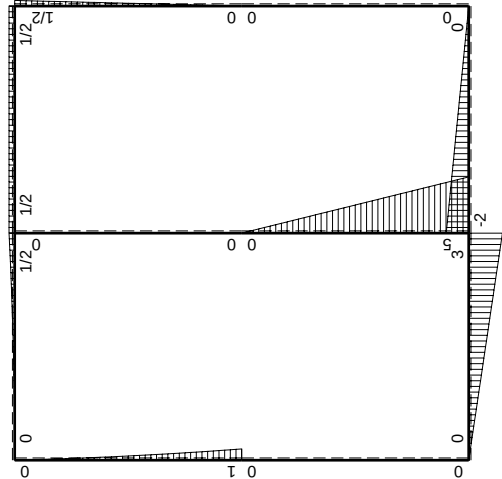
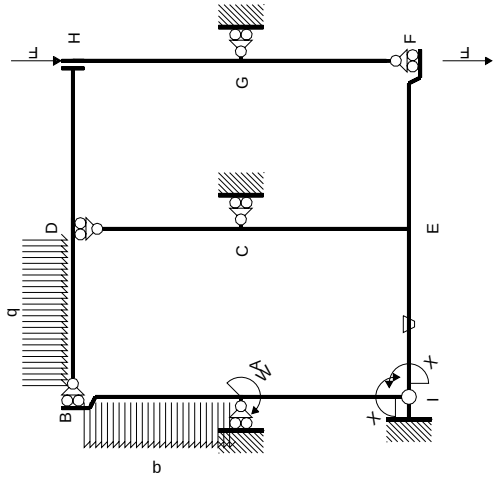
$$\sigma_c = -Mv/J_u = 143.2 \text{ N/mm}^2$$

$$\tau_c = 6.387 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 143.6 \text{ N/mm}^2$$

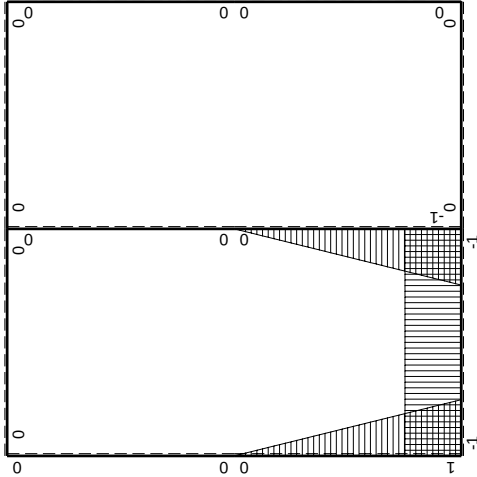
$$S = 3225. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

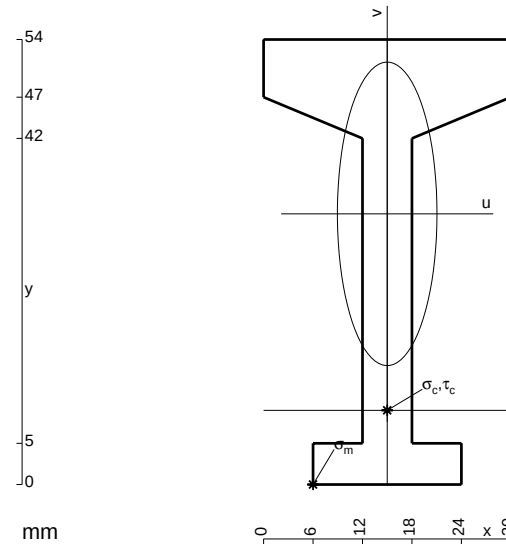
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$



$$A = 612. \text{ mm}^2$$

$$J_u = 207668. \text{ mm}^4$$

$$J_v = 22356. \text{ mm}^4$$

$$y_g = 32.85 \text{ mm}$$

$$T_y = 2240. \text{ N}$$

$$M_x = -1321600. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -32.85 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -209. \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

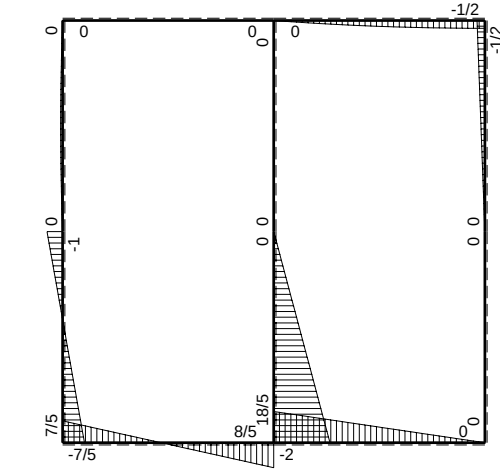
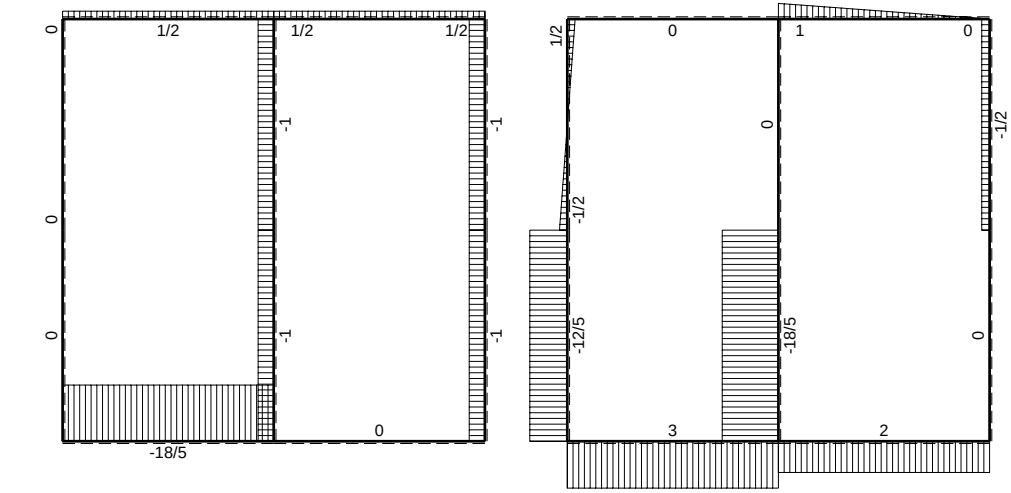
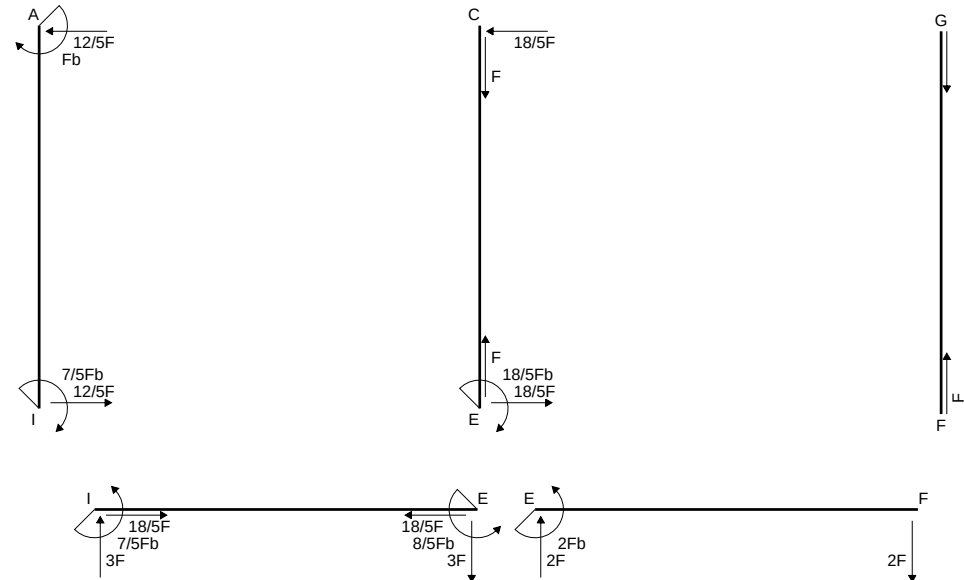
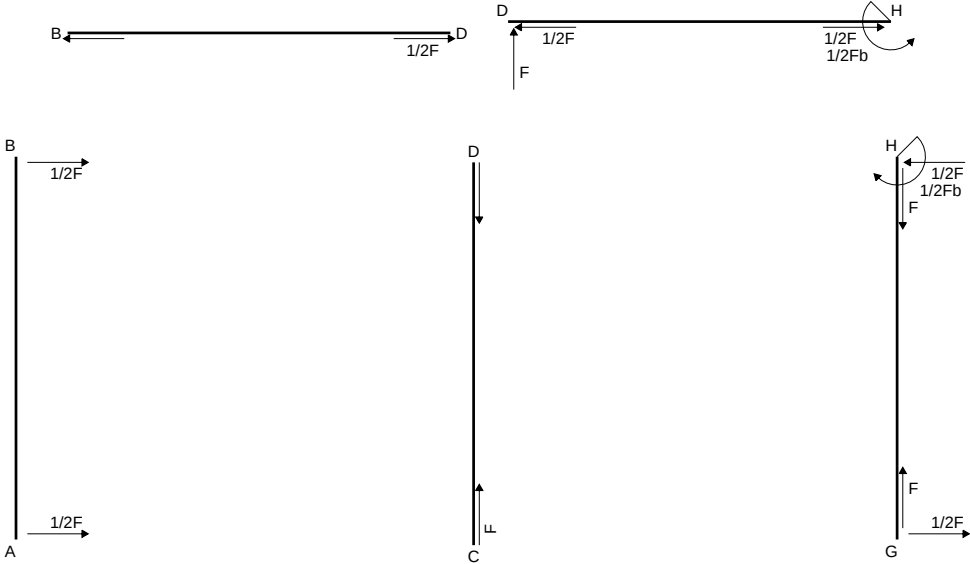
$$v_c = -23.85 \text{ mm}$$

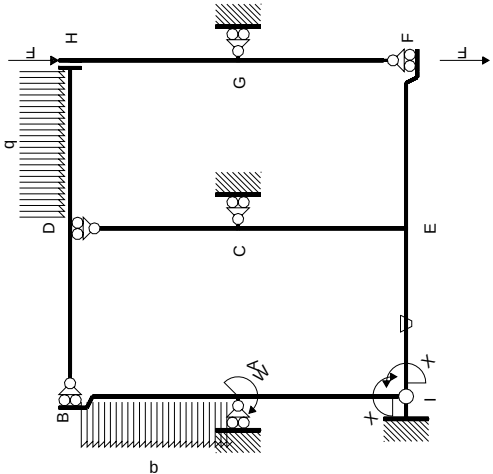
$$\sigma_c = -Mv/J_u = -151.8 \text{ N/mm}^2$$

$$\tau_c = 6.025 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 152.1 \text{ N/mm}^2$$

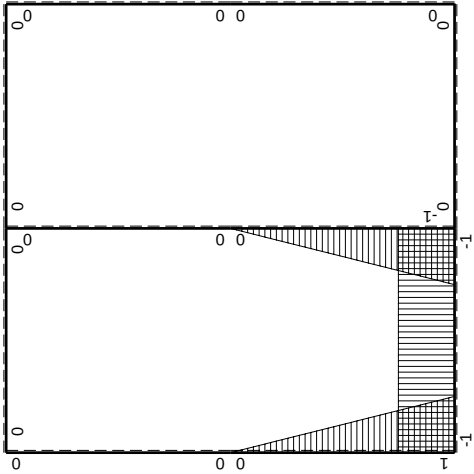
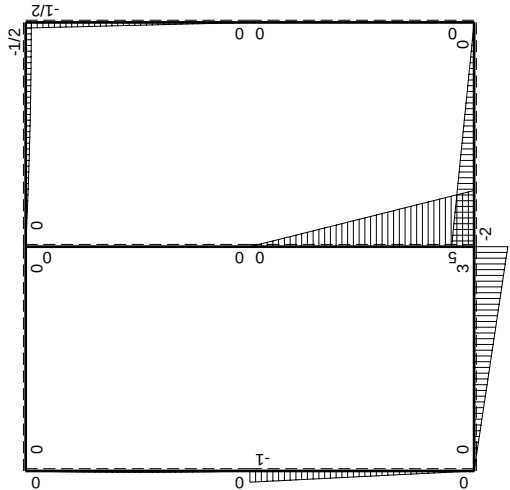
$$S = 3351. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

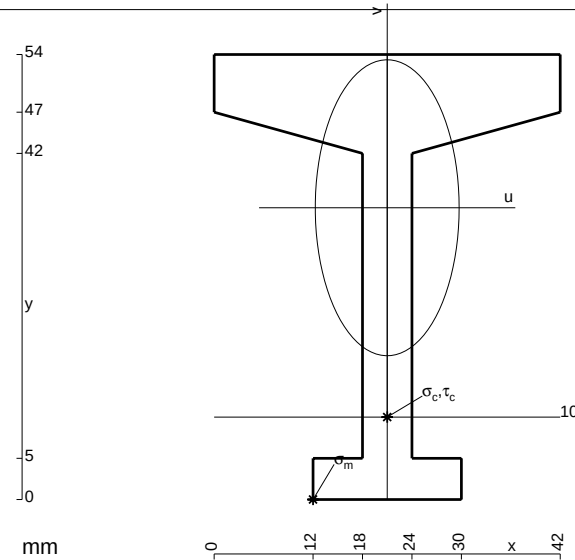
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 726. \text{ mm}^2$$

$$J_u = 234156. \text{ mm}^4$$

$$J_v = 55314. \text{ mm}^4$$

$$y_g = 35.4 \text{ mm}$$

$$T_y = 2260. \text{ N}$$

$$M_x = -1446400. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -35.4 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218.7 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

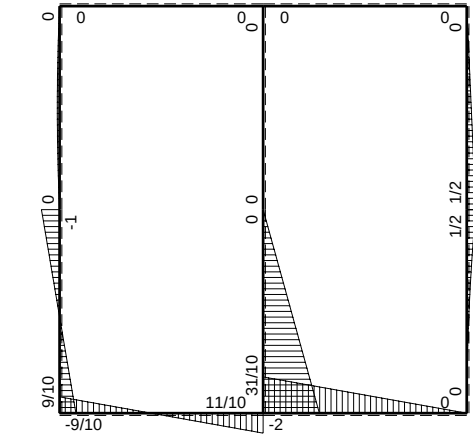
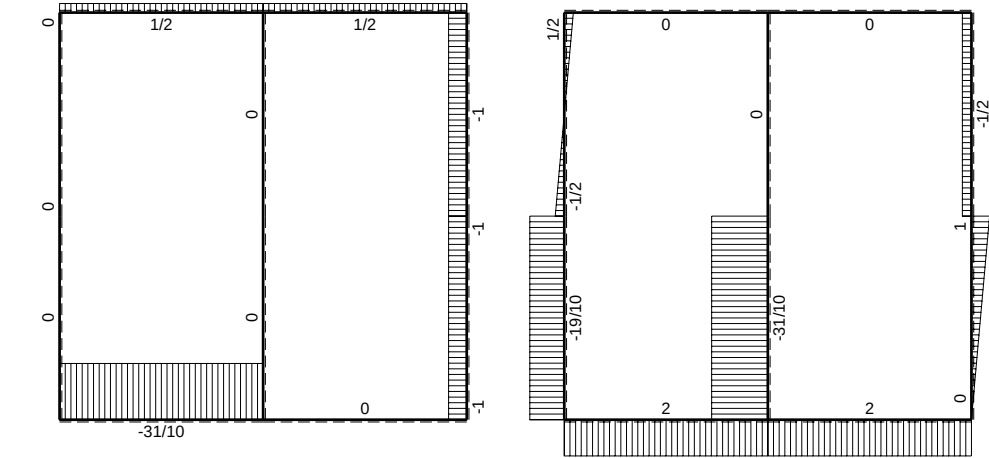
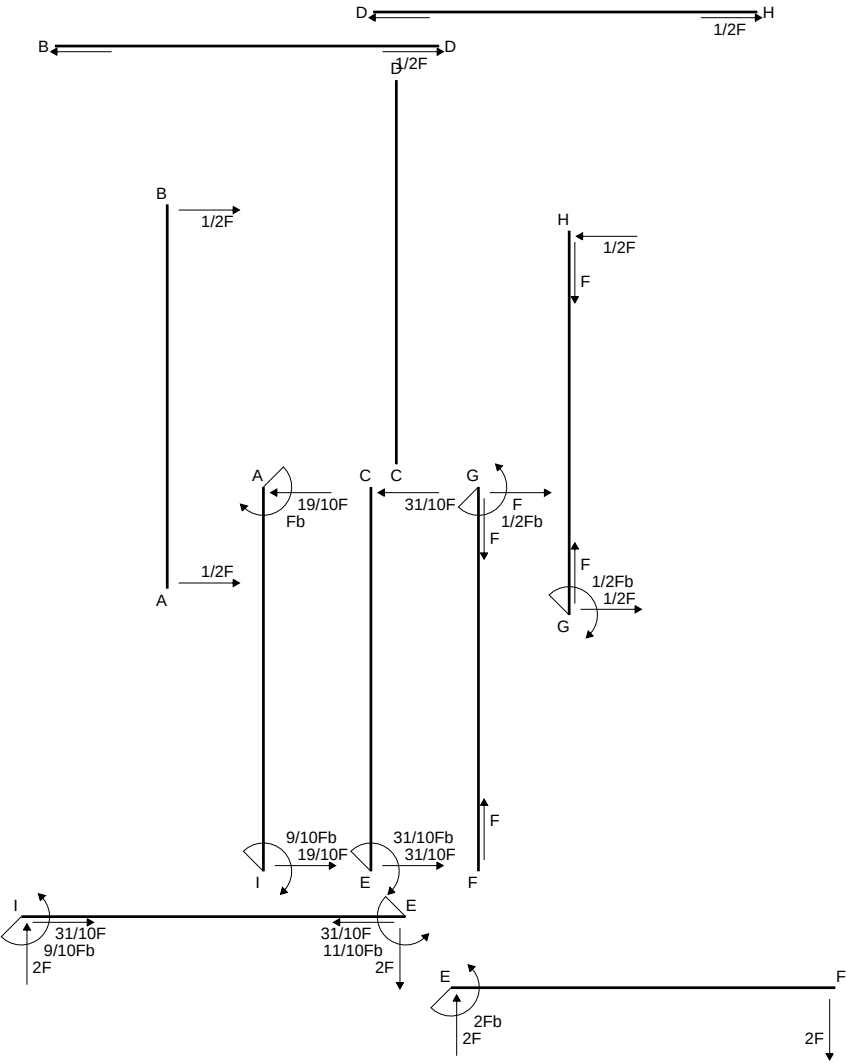
$$v_c = -25.41 \text{ mm}$$

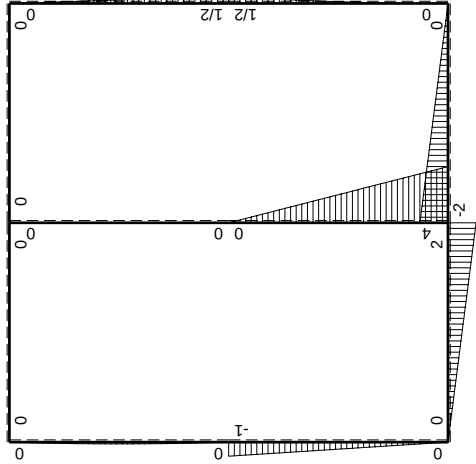
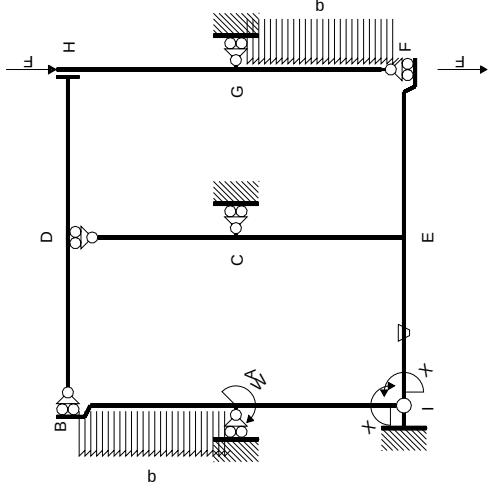
$$\sigma_c = -Mv/J_u = -156.9 \text{ N/mm}^2$$

$$\tau_c = 6.11 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 157.3 \text{ N/mm}^2$$

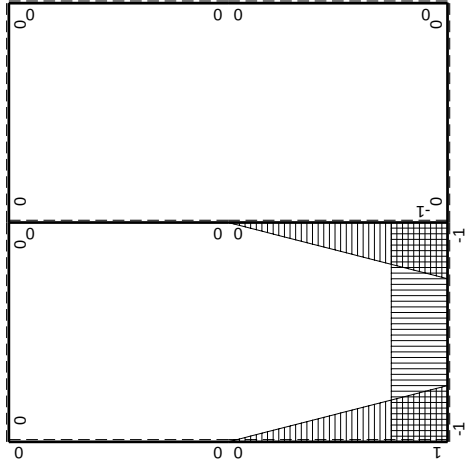
$$S = 3799. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

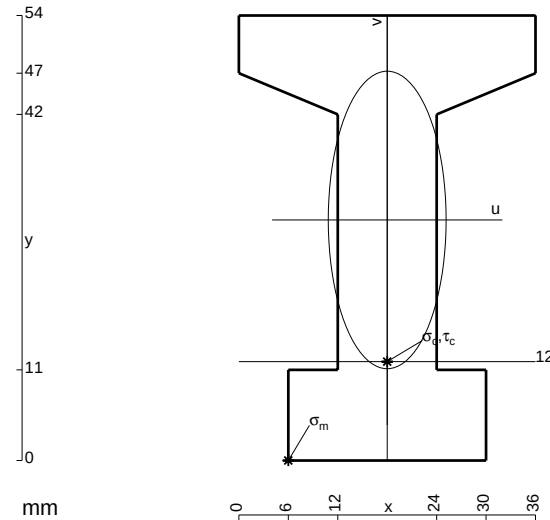
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1008. \text{ mm}^2$$

$$J_u = 328681. \text{ mm}^4$$

$$J_v = 51552. \text{ mm}^4$$

$$y_g = 29.19 \text{ mm}$$

$$T_y = 3680. \text{ N}$$

$$M_x = -2576000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -29.19 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -228.8 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

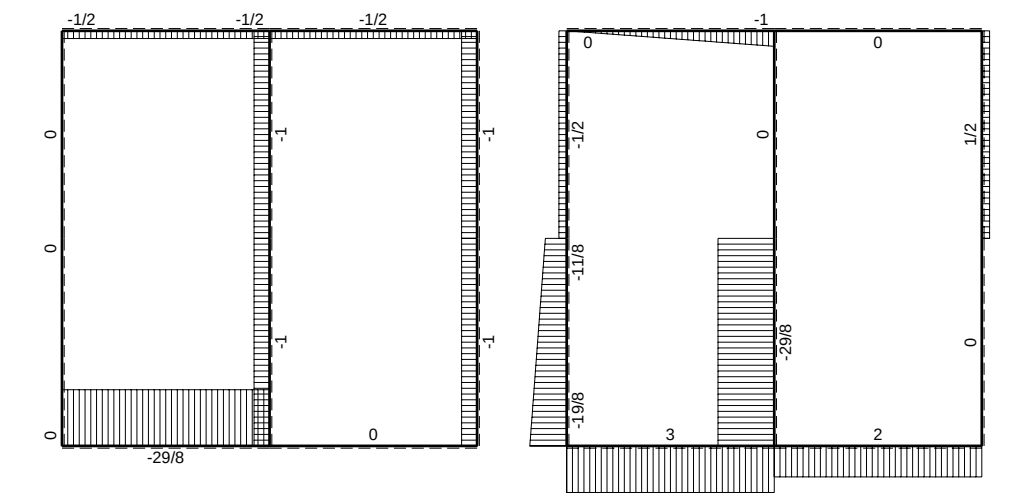
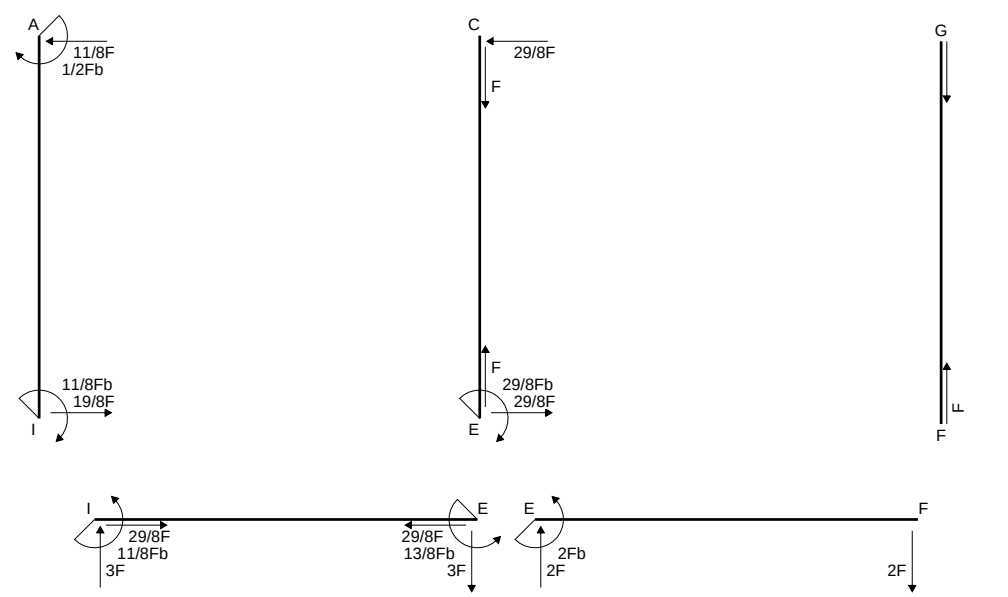
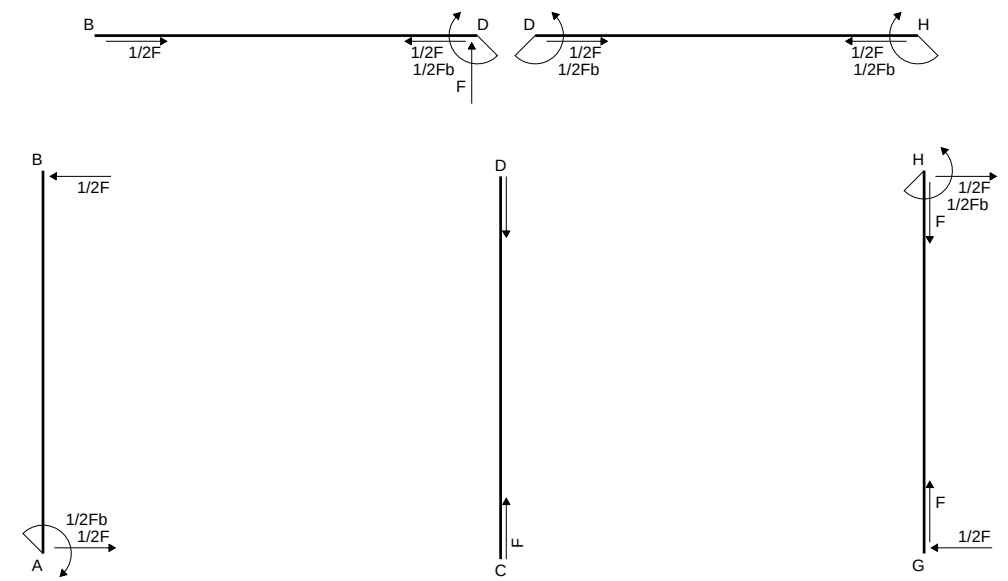
$$v_c = -17.19 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -134.7 \text{ N/mm}^2$$

$$\tau_c = 6.034 \text{ N/mm}^2$$

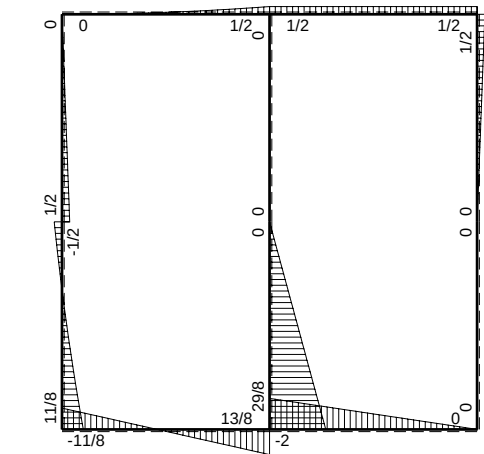
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 135.1 \text{ N/mm}^2$$

$$S = 6467. \text{ mm}^3$$

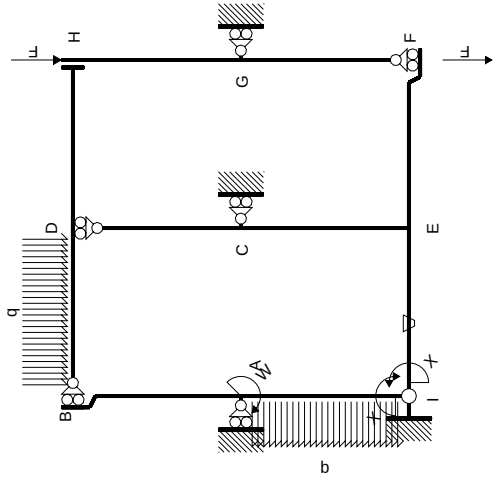


← ⊕ → F

↑ ⊕ ↓ F

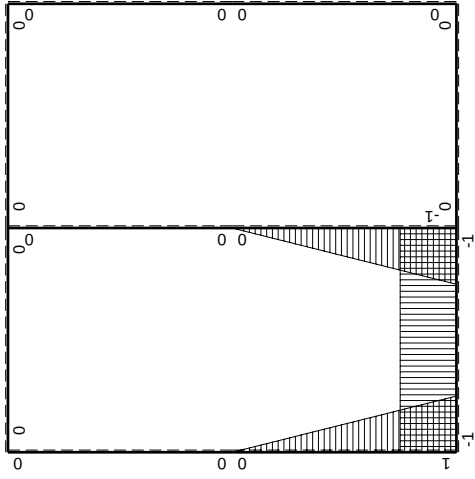
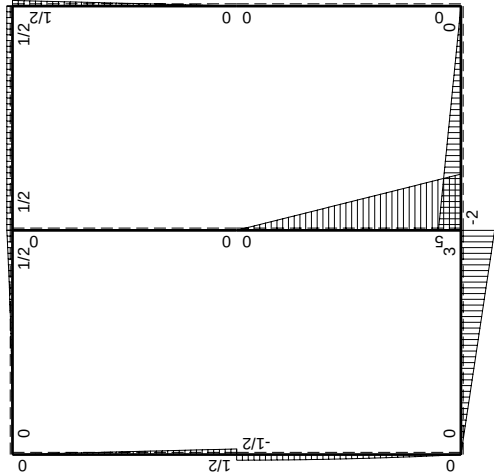


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx+1/2qx^2$	0	$-Fx+3/2Fx^2/b-1/2qx^3/b$	0	$1-2x/b+x^2/b^2$	$(-1/8+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2qx^2$	0	$-1/2Fb+1/2qx^3/b$	0	x^2/b^2		
	totali						$-55/24Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$11/8Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

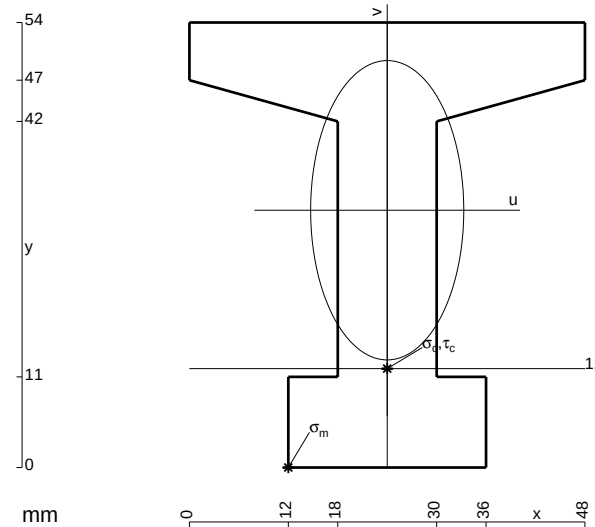
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (-x/b + 3/2 x^2/b^2 - 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/2 x^3/b^2 - 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

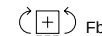
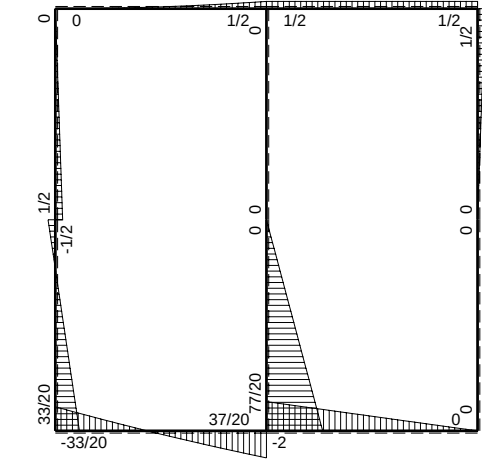
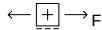
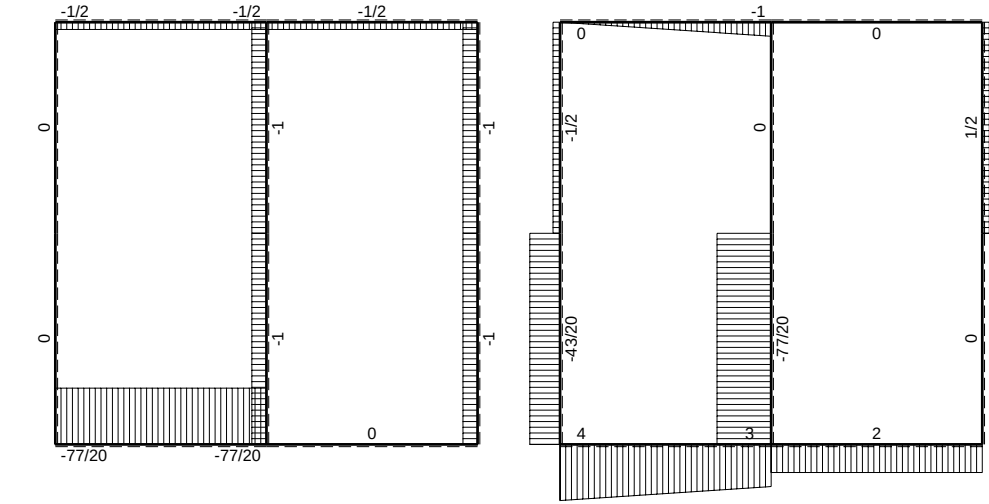
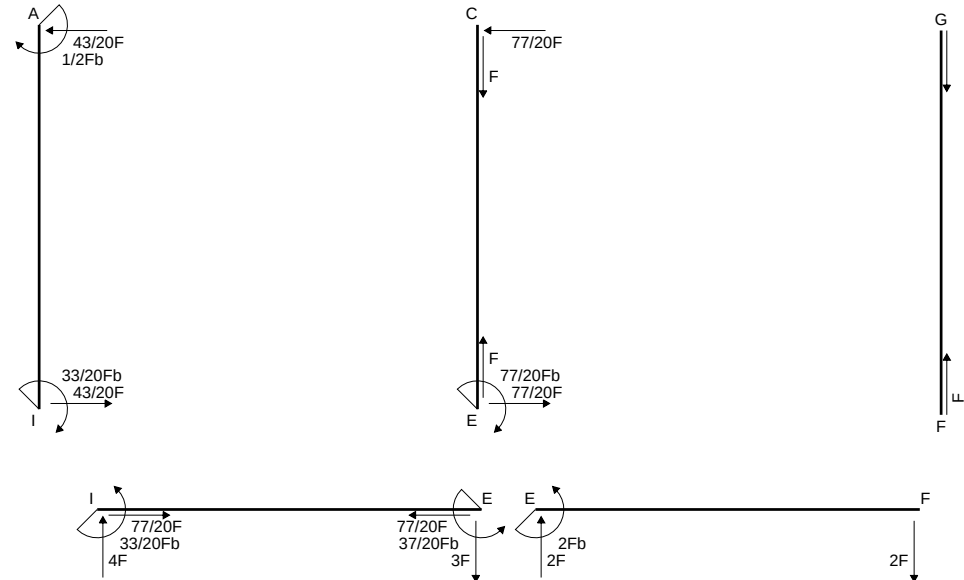
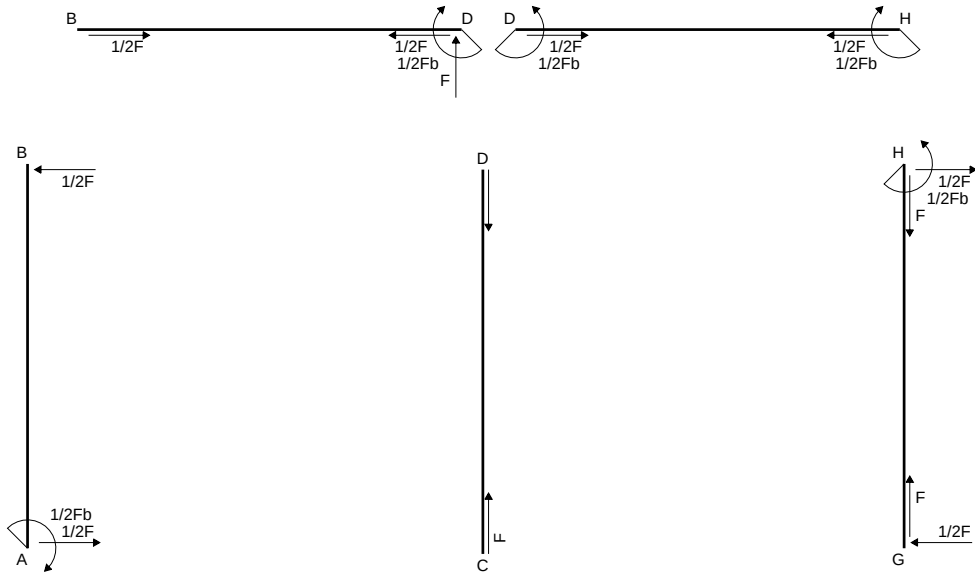
$$= (-1/2 b + 1/2 b - 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$

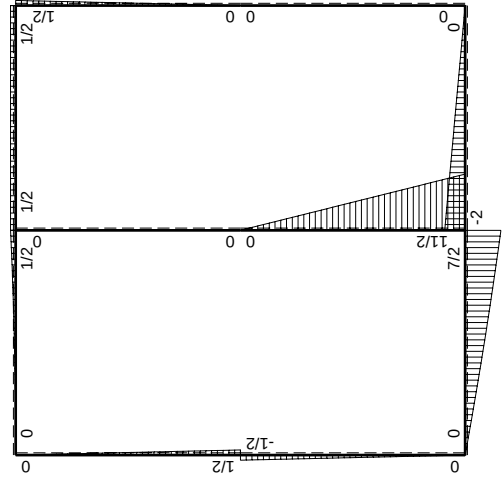
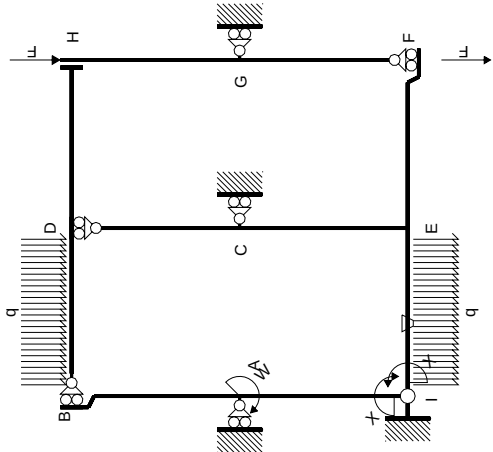
$$L_{AI}^{x\theta} = \int_0^b (-1/2 x/b + 1/2 x^3/b^3) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/8 x^4/b^3 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/8 b) Fb \frac{1}{EJ} = -1/8 Fb^2/EJ$$



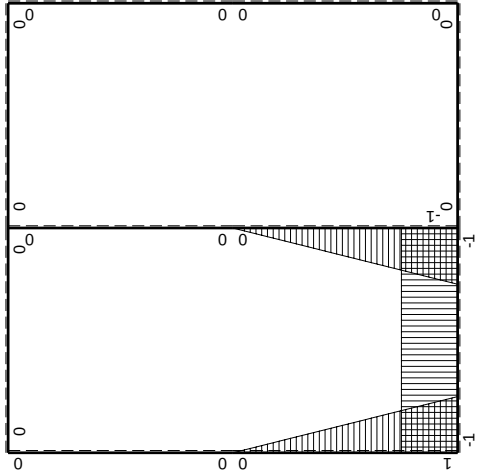
$$\begin{aligned} A &= 1122. \text{ mm}^2 \\ J_u &= 370409. \text{ mm}^4 \\ J_v &= 96948. \text{ mm}^4 \\ y_g &= 31.22 \text{ mm} \\ T_y &= 3780. \text{ N} \\ M_x &= -2835000. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -31.22 \text{ mm} \\ \sigma_m &= -Mv/J_u = -238.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -19.22 \text{ mm} \\ \sigma_c &= -Mv/J_u = -147.1 \text{ N/mm}^2 \\ \tau_c &= 5.975 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 147.5 \text{ N/mm}^2 \\ S &= 7027. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$1/2Fb-1/2Fx$	0	$-1/2Fx+1/2Fx^2/b$	0	x^2/b^2		
	totali						$-11/4Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$33/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

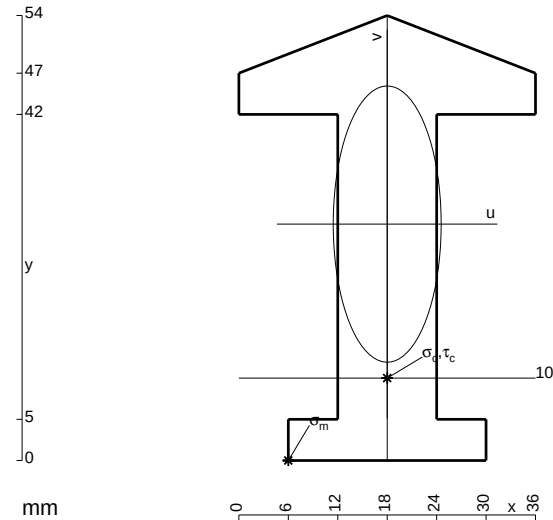
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



$$A = 870. \text{ mm}^2$$

$$J_u = 244577. \text{ mm}^4$$

$$J_v = 37332. \text{ mm}^4$$

$$y_g = 28.69 \text{ mm}$$

$$T_y = 2100. \text{ N}$$

$$M_x = -1701000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.69 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.5 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

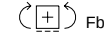
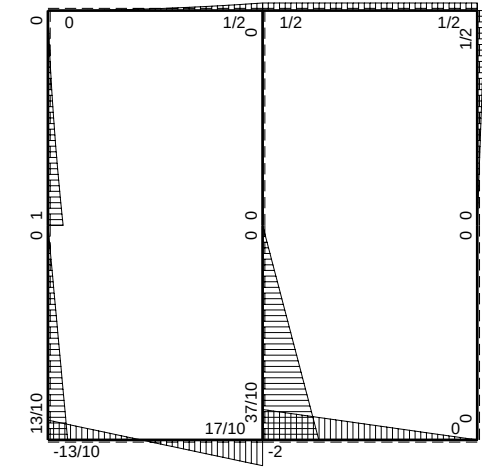
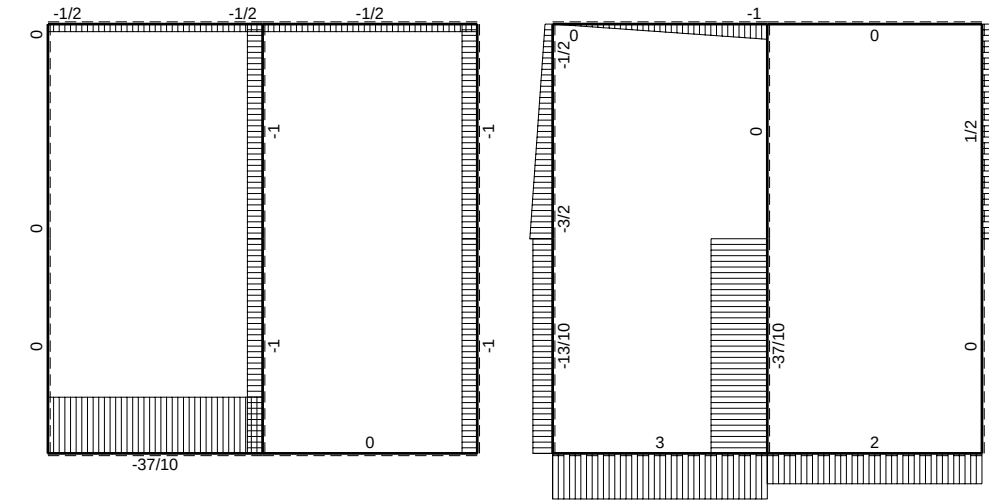
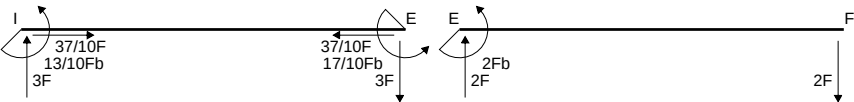
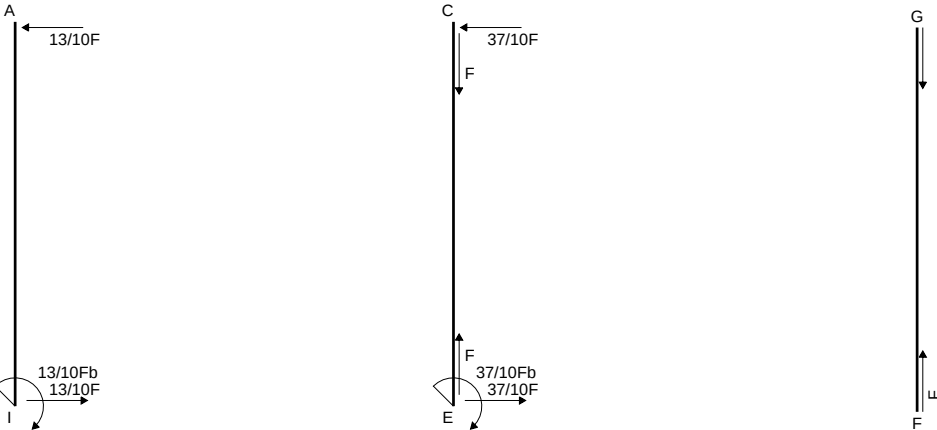
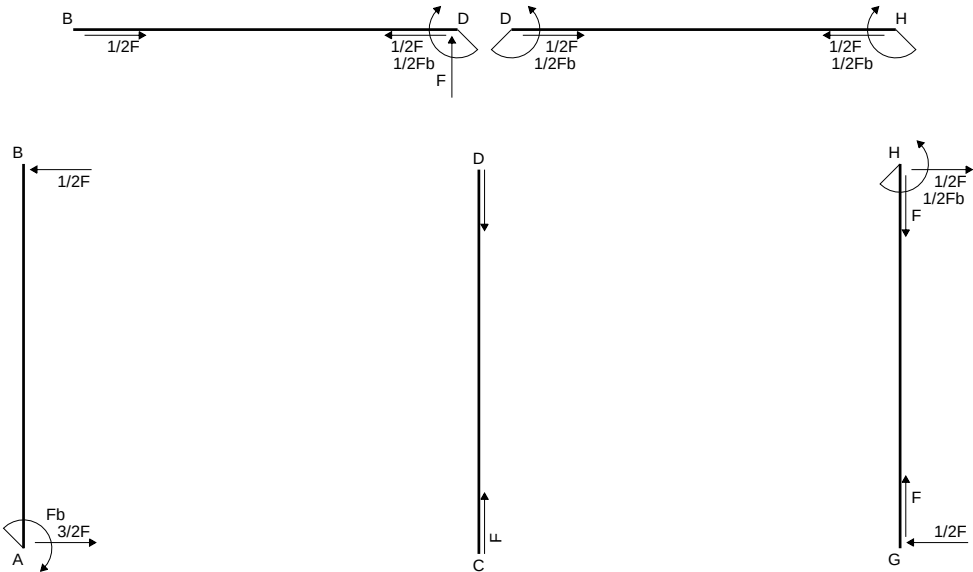
$$v_c = -18.69 \text{ mm}$$

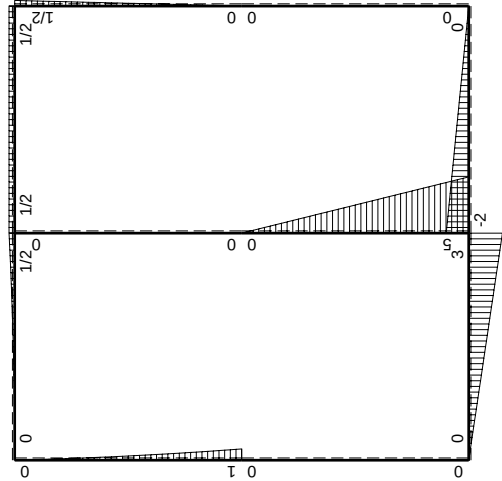
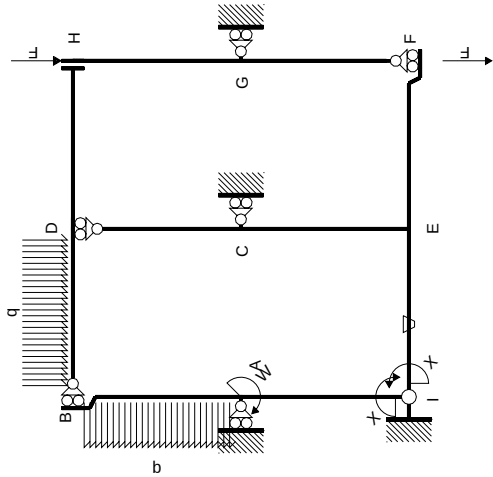
$$\sigma_c = -Mv/J_u = -130. \text{ N/mm}^2$$

$$\tau_c = 3.158 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 130.1 \text{ N/mm}^2$$

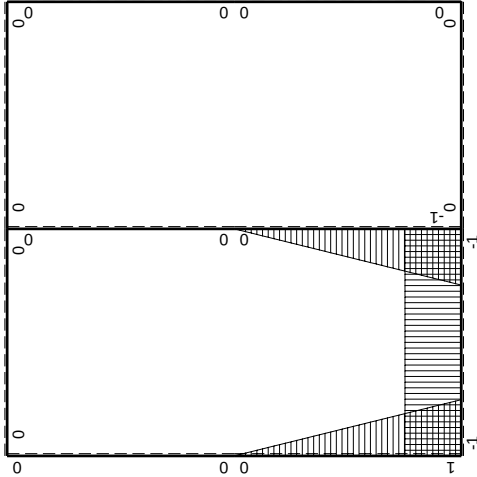
$$S = 4414. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_0 flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	$Fb-3/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$-1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+1/2Fx$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

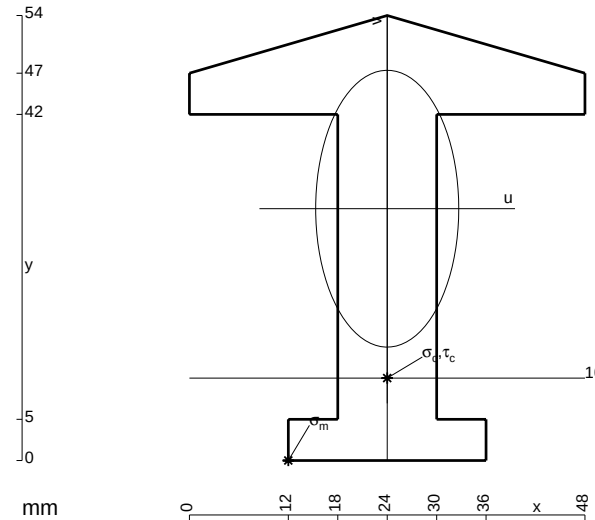
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

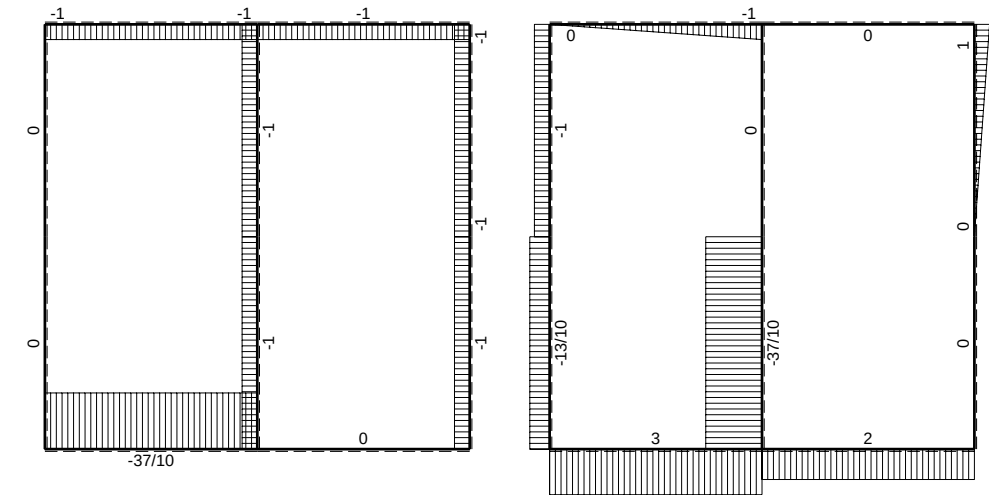
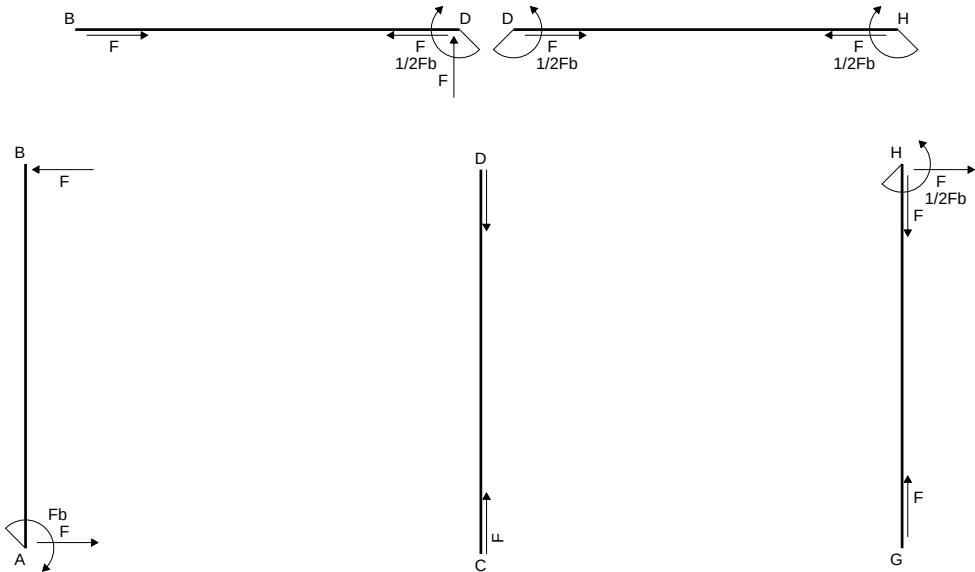
$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

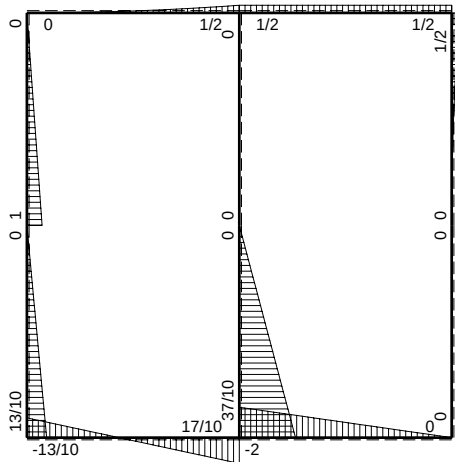
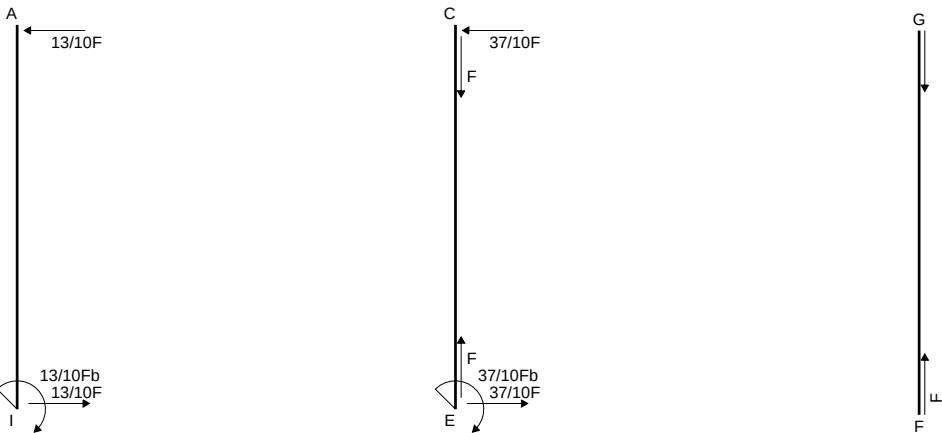


$$\begin{aligned} A &= 972. \text{ mm}^2 \\ J_u &= 274322. \text{ mm}^4 \\ J_v &= 73296. \text{ mm}^4 \\ y_g &= 30.56 \text{ mm} \\ T_y &= 2180. \text{ N} \\ M_x &= -1874800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.56 \text{ mm} \\ \sigma_m &= -Mv/J_u = -208.8 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -20.56 \text{ mm} \\ \sigma_c &= -Mv/J_u = -140.5 \text{ N/mm}^2 \\ \tau_c &= 3.146 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 140.6 \text{ N/mm}^2 \\ S &= 4750. \text{ mm}^3 \end{aligned}$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊕ Fb

Quadro contributi PLV per iperstatica $X=W_{IE}$

$\rightarrow$	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-Fx$	0	0	0	0	0+0	0
BA b	0	$-Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

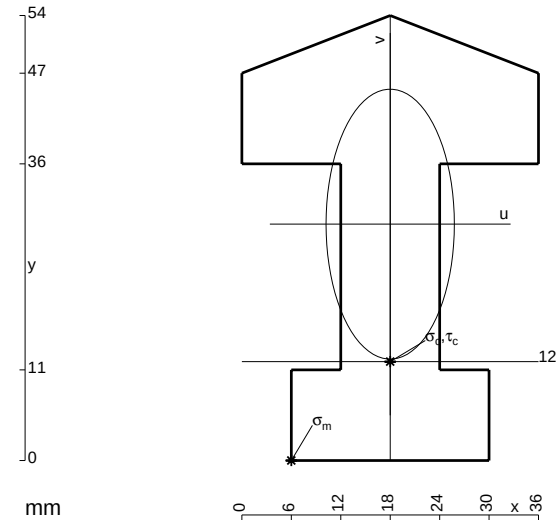
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

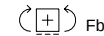
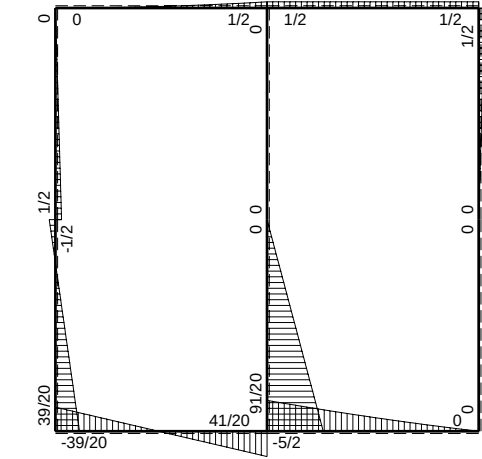
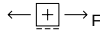
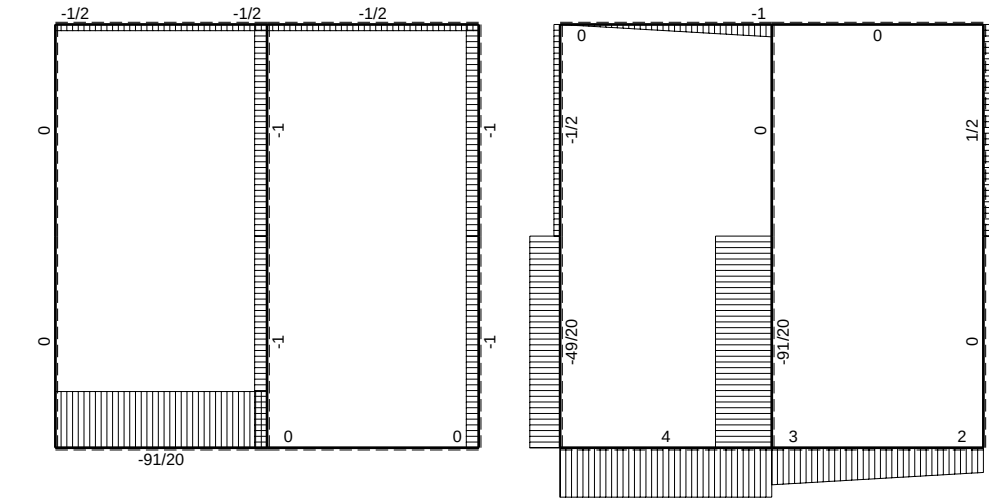
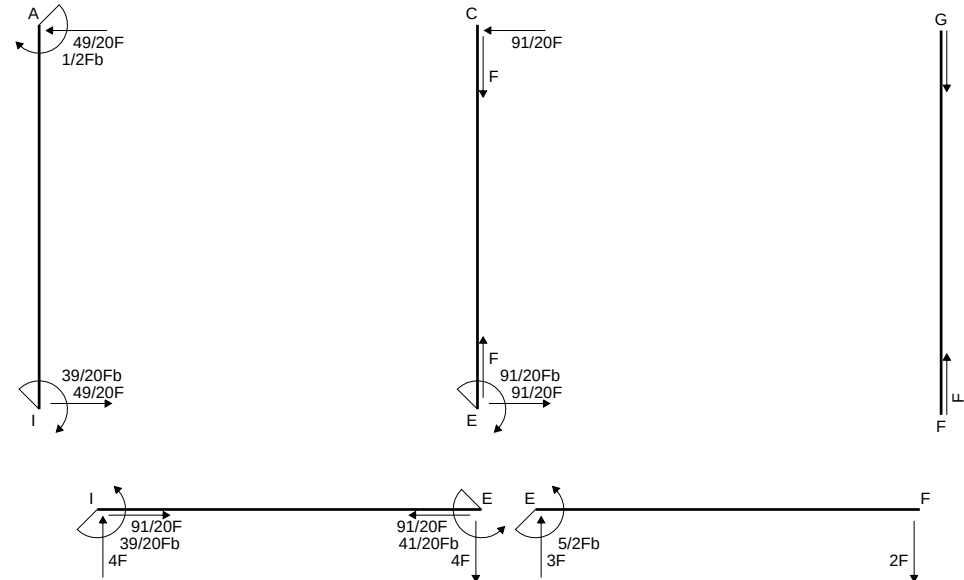
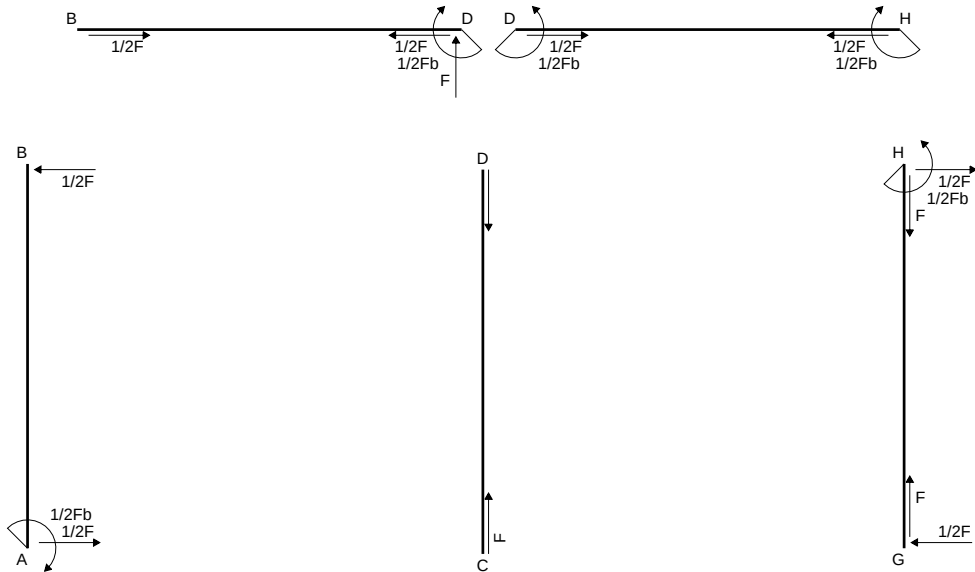
$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

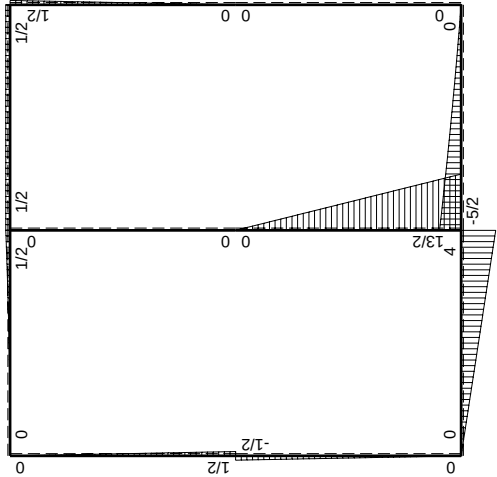
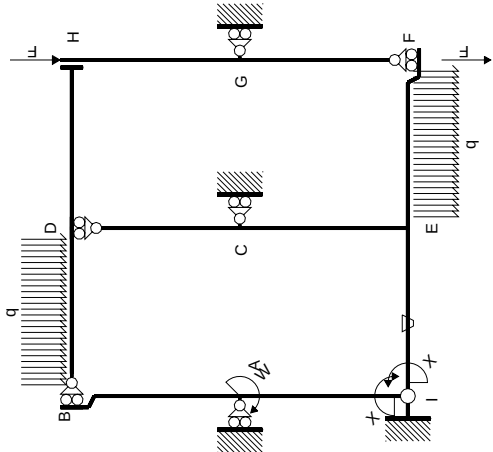
$$L_{CE}^{x0} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$



$$\begin{aligned} A &= 1086. \text{ mm}^2 \\ J_u &= 291353. \text{ mm}^4 \\ J_v &= 65844. \text{ mm}^4 \\ y_g &= 28.69 \text{ mm} \\ T_y &= 2440. \text{ N} \\ M_x &= -2220400. \text{ Nmm} \\ x_m &= 6. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -28.69 \text{ mm} \\ \sigma_m &= -Mv/J_u = -218.6 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -16.69 \text{ mm} \\ \sigma_c &= -Mv/J_u = -127.2 \text{ N/mm}^2 \\ \tau_c &= 4.416 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 127.4 \text{ N/mm}^2 \\ S &= 6327. \text{ mm}^3 \end{aligned}$$





Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2 Fb - 1/2 Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2 Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2 Fb + 3Fx - 1/2 qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx + 1/2 qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2 Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2 Fb + 1/2 Fx$	0	0	0	0		
HD b	0	$1/2 Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2 Fb$	0	0	0	0		
DB b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2 qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2 Fb - 13/2 Fx$	0	$-13/2 Fb + 13Fx - 13/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3 Xb/EJ$
CE b	x/b	$-13/2 Fx$	0	$-13/2 Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2 Fx$	0	$-1/2 Fx + 1/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3 Xb/EJ$
AI b	$-x/b$	$1/2 Fb - 1/2 Fx$	0	$-1/2 Fx + 1/2 Fx^2/b$	0	x^2/b^2		
	totali						$-13/4 Fb^2/EJ$	$5/3 Xb/EJ$
	iperstatica $X=W_{IE}$						$39/20 Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

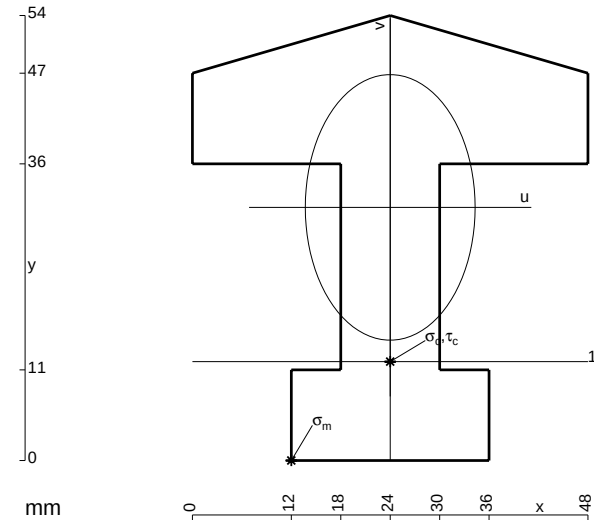
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

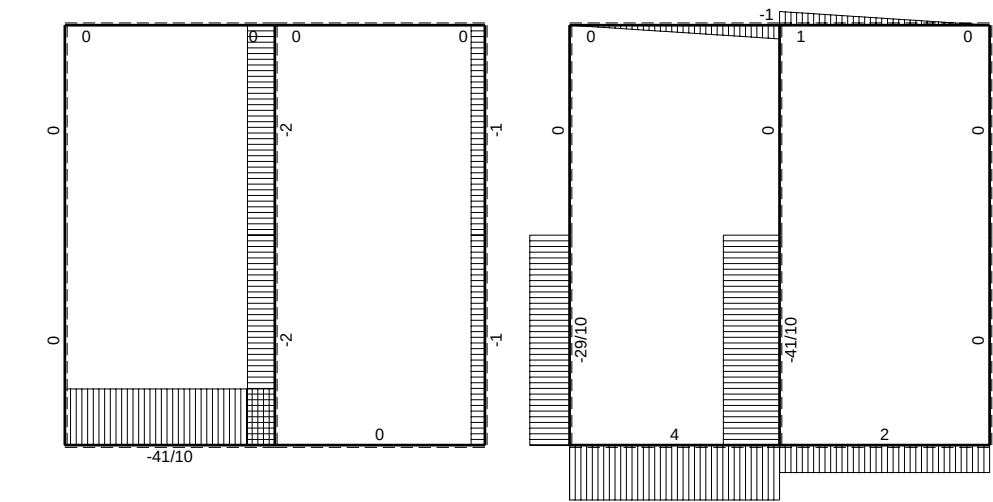
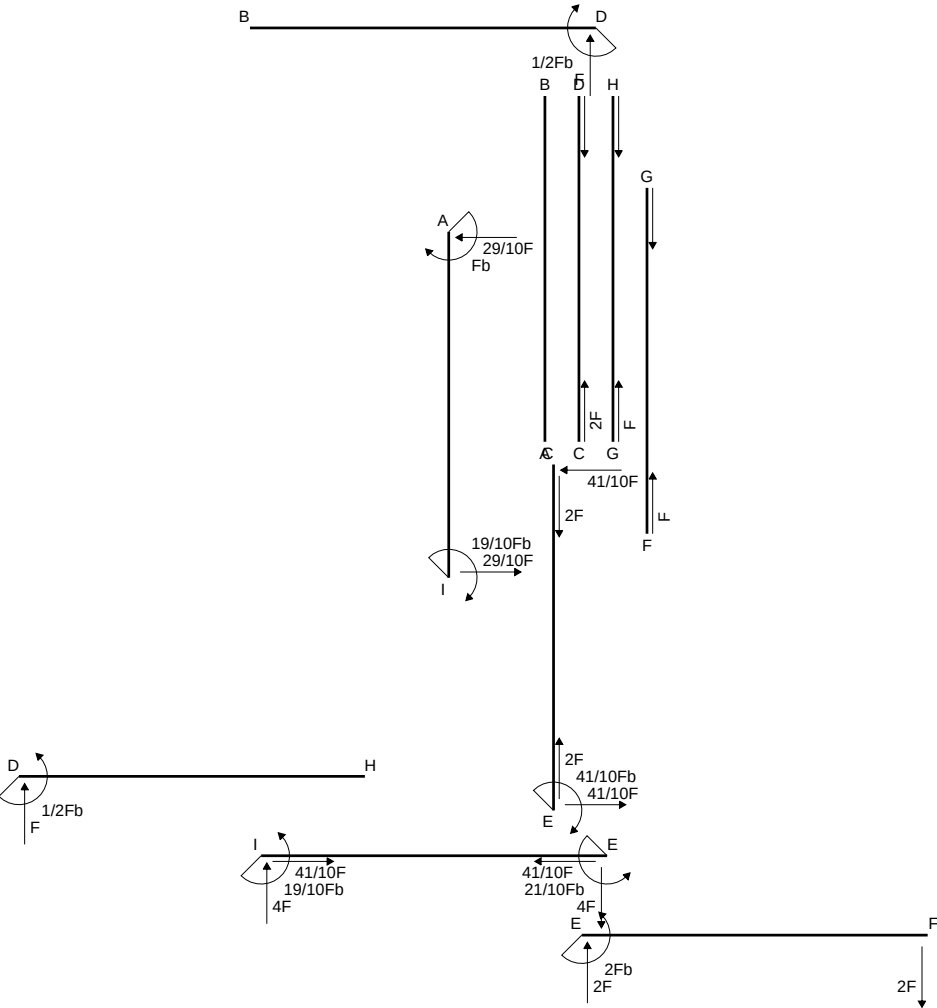
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

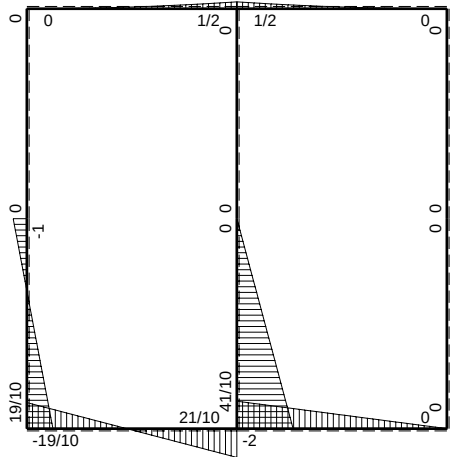


$$\begin{aligned} A &= 1260. \text{ mm}^2 \\ J_u &= 327186. \text{ mm}^4 \\ J_v &= 133776. \text{ mm}^4 \\ y_g &= 30.72 \text{ mm} \\ T_y &= 3030. \text{ N} \\ M_x &= -2449250. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.72 \text{ mm} \\ \sigma_m &= -Mv/J_u = -229.9 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -18.72 \text{ mm} \\ \sigma_c &= -Mv/J_u = -140.1 \text{ N/mm}^2 \\ \tau_c &= 5.315 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 140.4 \text{ N/mm}^2 \\ S &= 6888. \text{ mm}^3 \end{aligned}$$

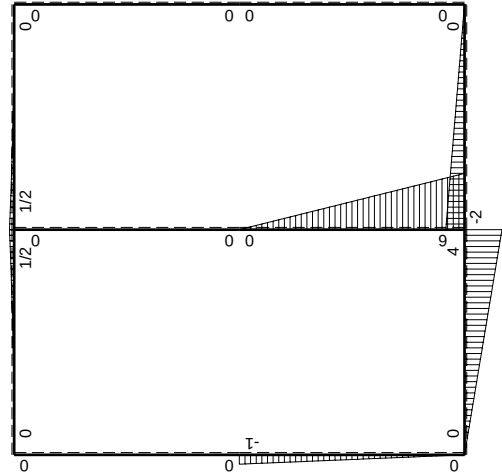
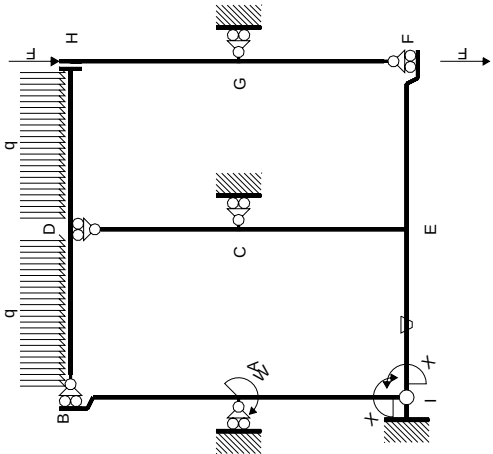


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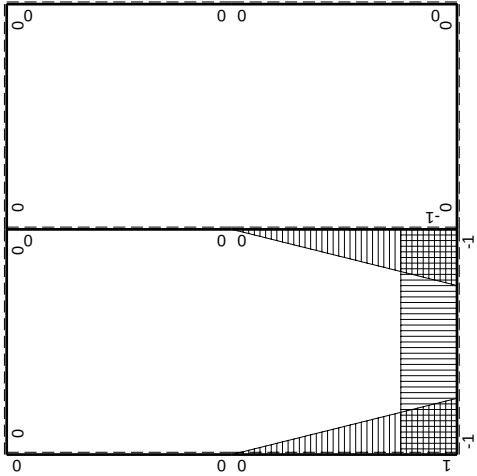


⊕ ⊕ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-19/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

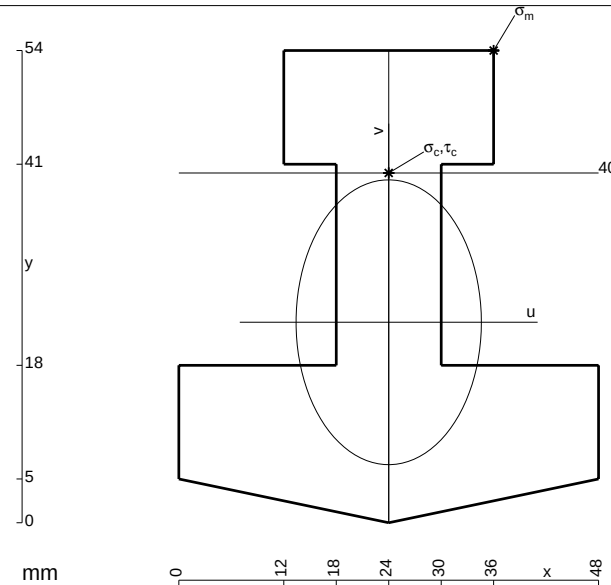
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1332. \text{ mm}^2$$

$$J_u = 353385. \text{ mm}^4$$

$$J_v = 149616. \text{ mm}^4$$

$$y_g = 22.93 \text{ mm}$$

$$T_y = 2660. \text{ N}$$

$$M_x = -2713200. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 31.07 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 238.6 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

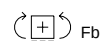
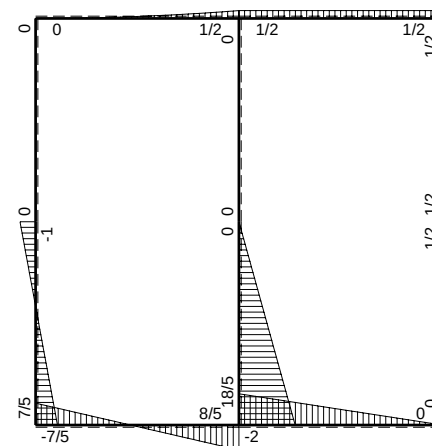
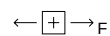
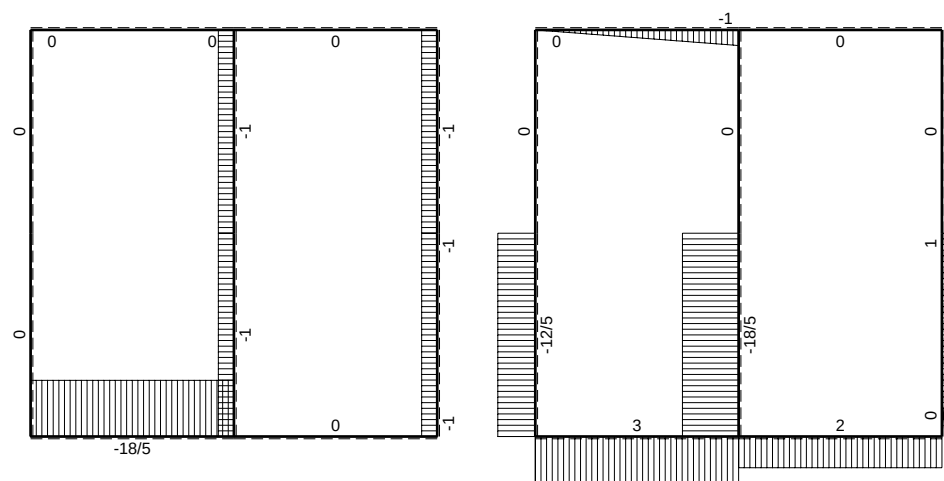
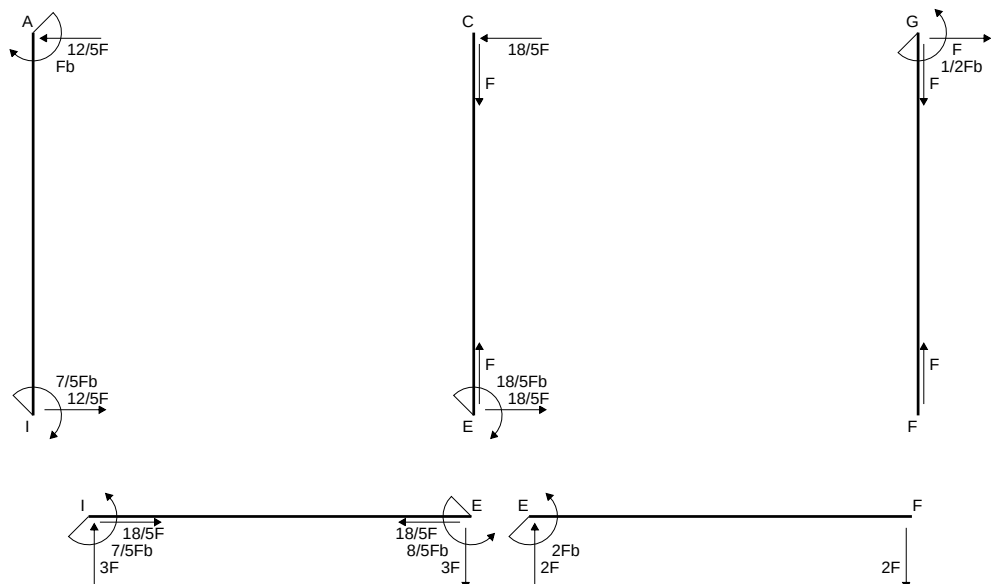
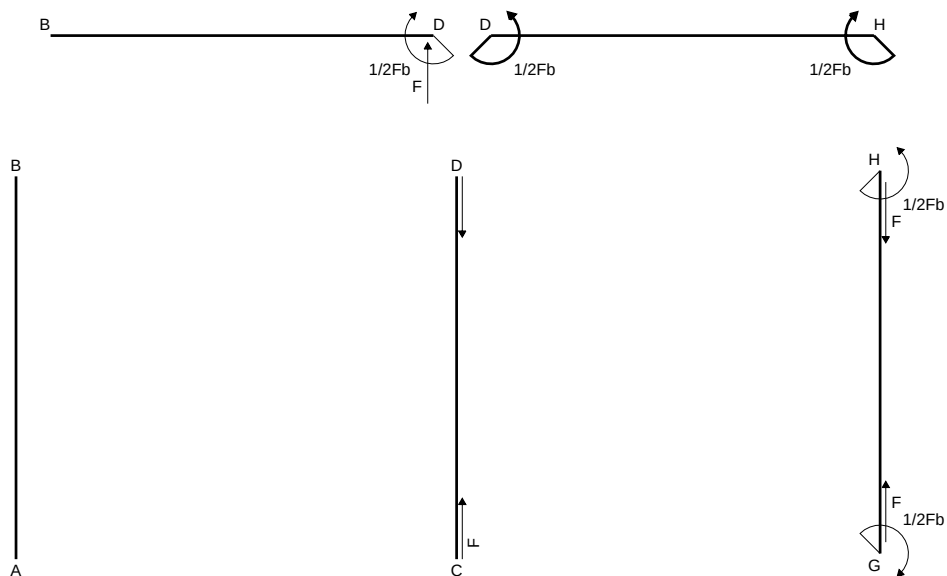
$$v_c = 17.07 \text{ mm}$$

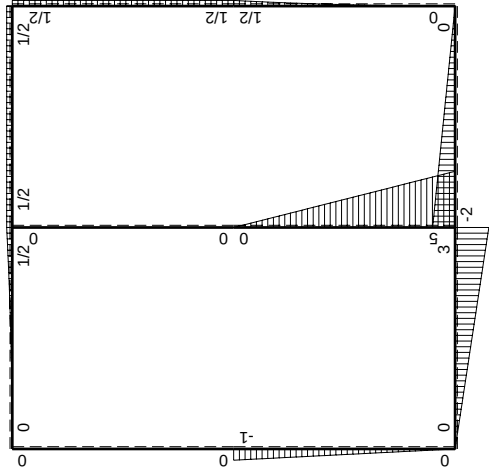
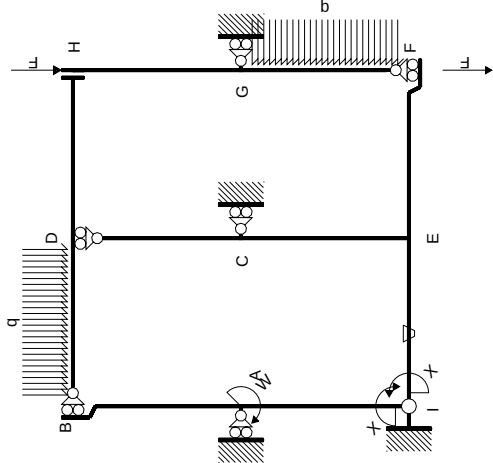
$$\sigma_c = -Mv/J_u = 131.1 \text{ N/mm}^2$$

$$\tau_c = 4.942 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 131.4 \text{ N/mm}^2$$

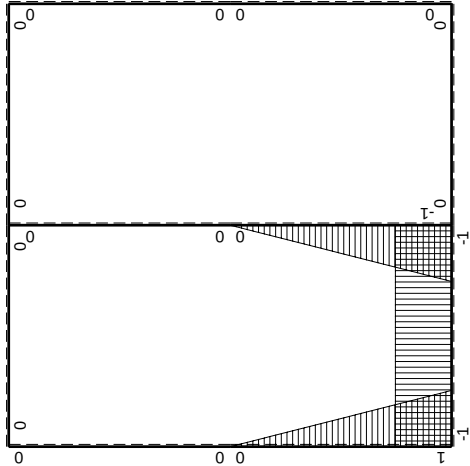
$$S = 7878. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

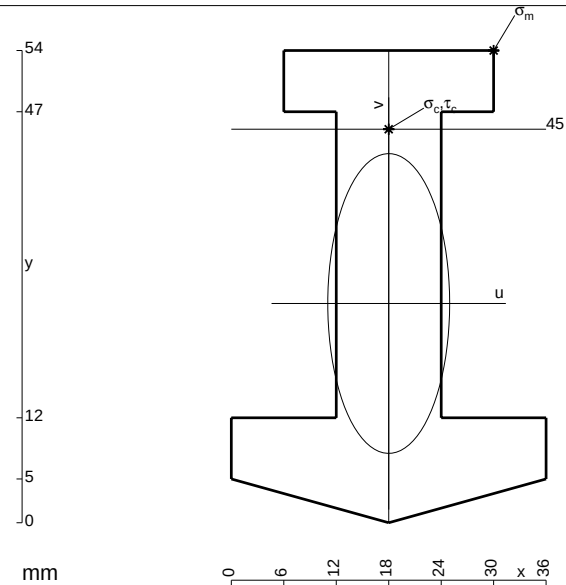
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 930. \text{ mm}^2$$

$$J_u = 273314. \text{ mm}^4$$

$$J_v = 45180. \text{ mm}^4$$

$$y_g = 25.07 \text{ mm}$$

$$T_y = 3480. \text{ N}$$

$$M_x = -1879200. \text{ Nmm}$$

$$x_m = 30. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 28.93 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 198.9 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 45. \text{ mm}$$

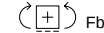
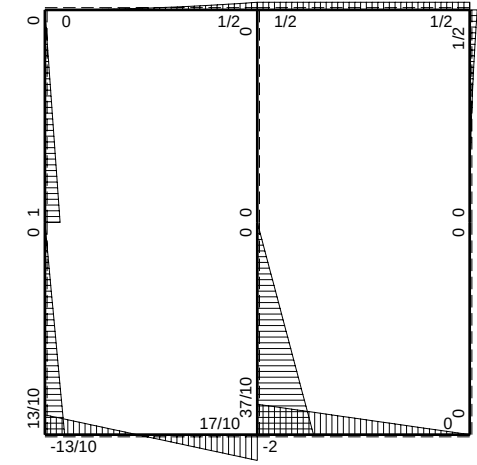
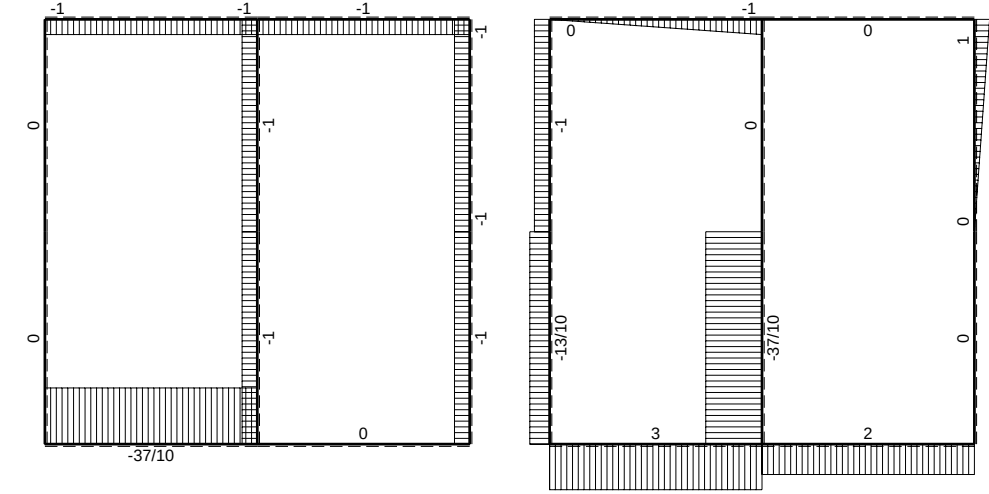
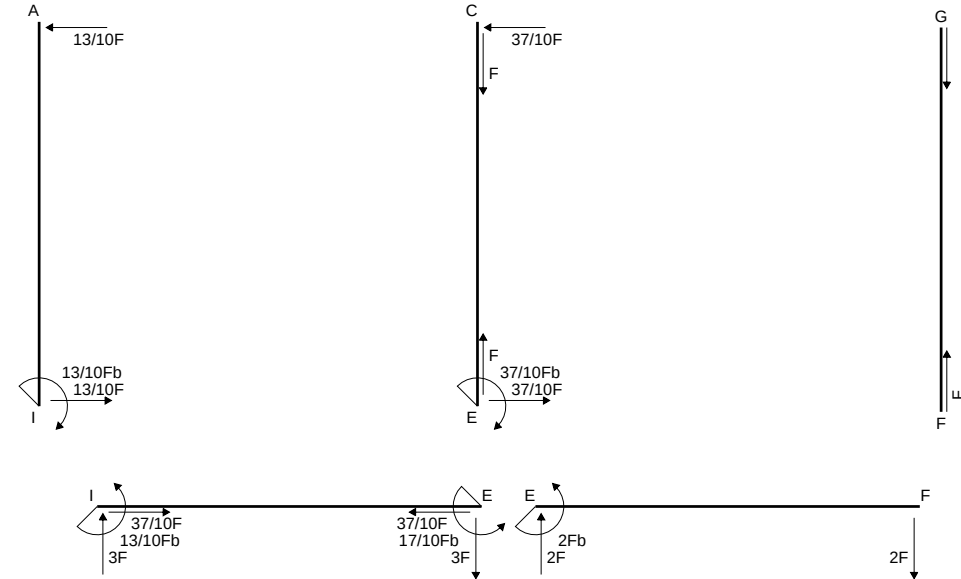
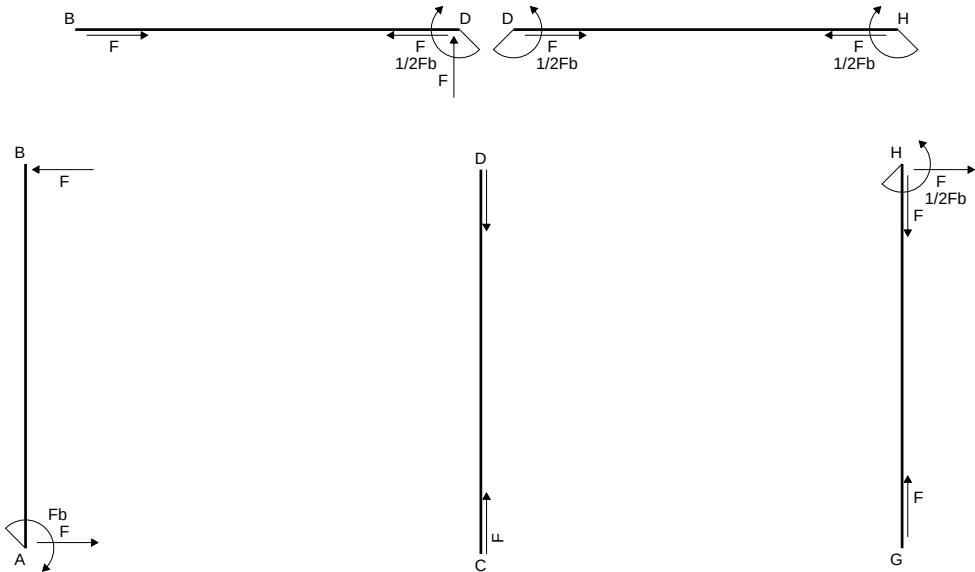
$$v_c = 19.93 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 137. \text{ N/mm}^2$$

$$\tau_c = 5.066 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 137.3 \text{ N/mm}^2$$

$$S = 4774. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$Fb-Fx$	0	0	0	0	0+0	0
BA b	0	$-Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
HD b	0	$1/2Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	0	0	0	0	$1-2x/b+x^2/b^2$	0+0	$1/3Xb/EJ$
AI b	$-x/b$	0	0	0	0	x^2/b^2		
	totali						$-13/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$13/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

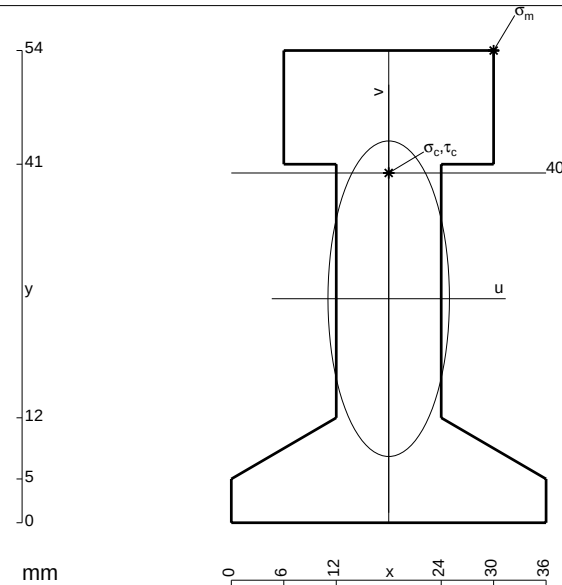
$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

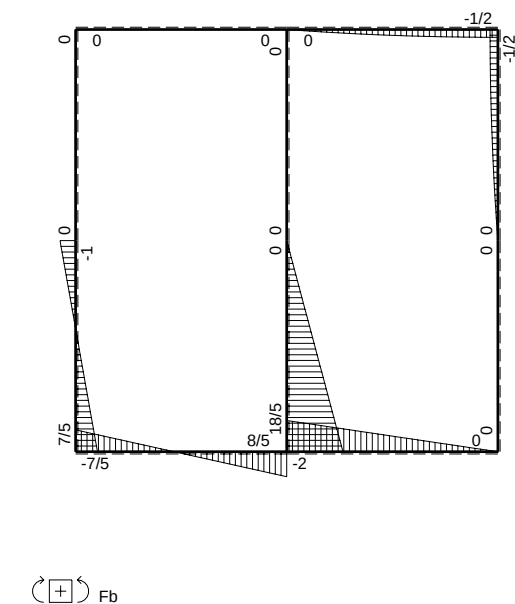
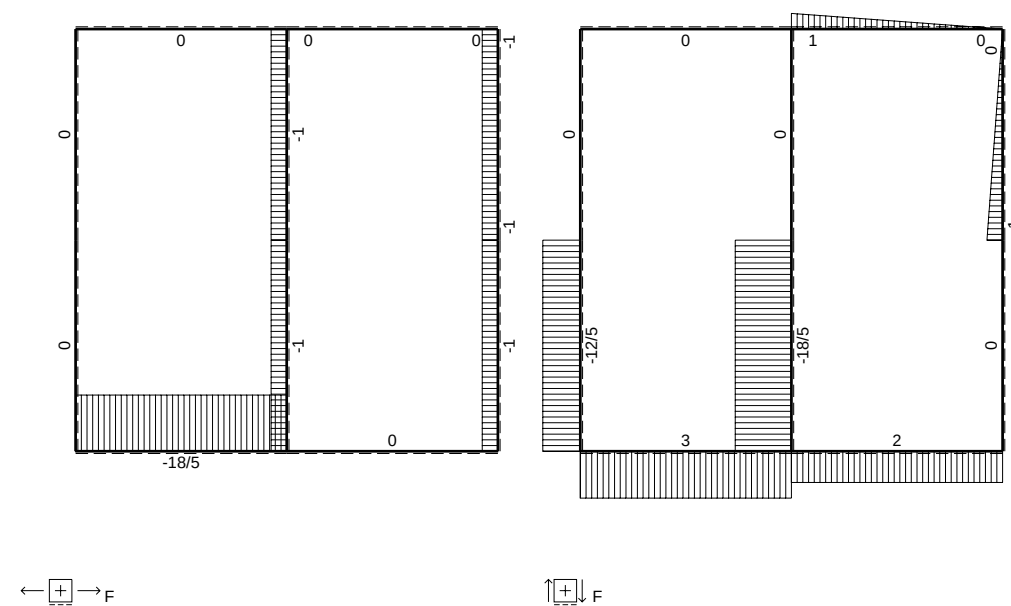
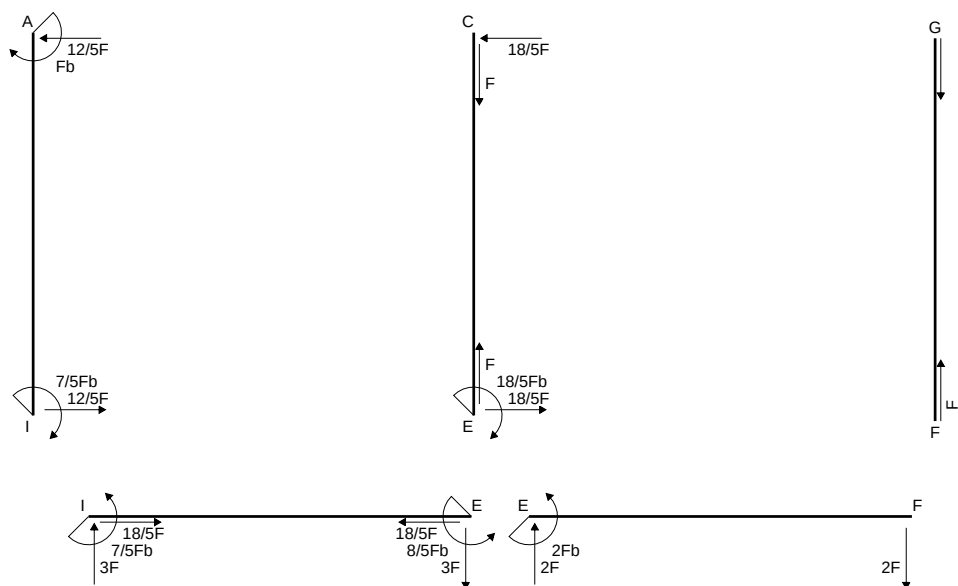
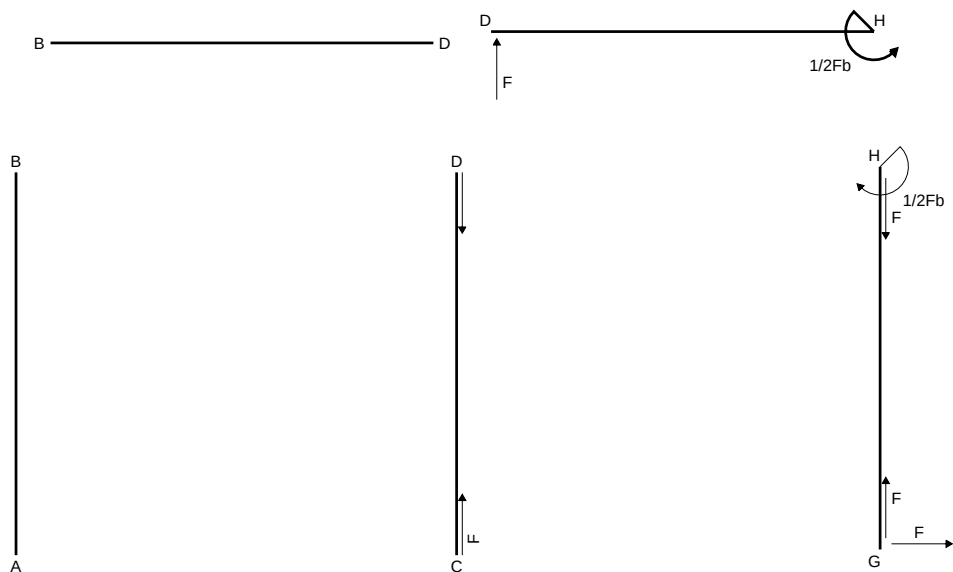
$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

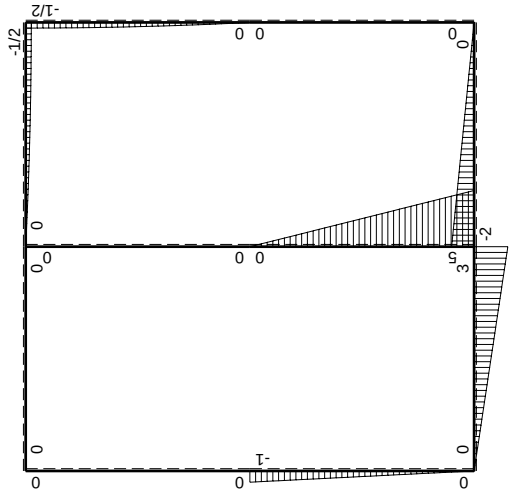
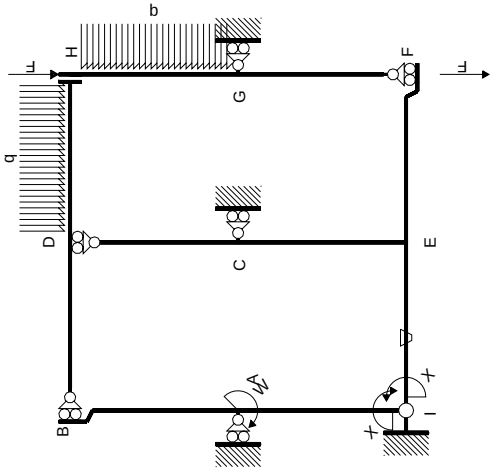
$$L_{CE}^{x0} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$



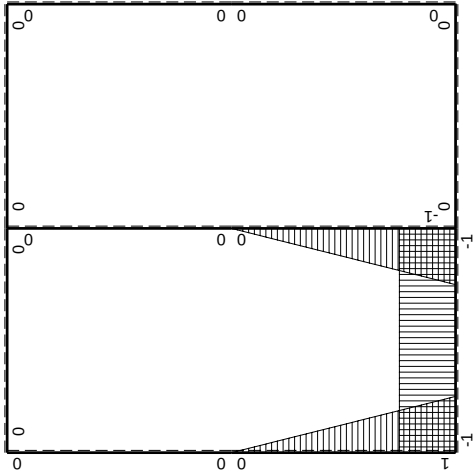
$$\begin{aligned} A &= 1008. \text{ mm}^2 \\ J_u &= 328290. \text{ mm}^4 \\ J_v &= 48672. \text{ mm}^4 \\ y_g &= 25.62 \text{ mm} \\ T_y &= 4100. \text{ N} \\ M_x &= -2419000. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 28.38 \text{ mm} \\ \sigma_m &= -Mv/J_u = 209.1 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 14.38 \text{ mm} \\ \sigma_c &= -Mv/J_u = 106. \text{ N/mm}^2 \\ \tau_c &= 7.292 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 106.7 \text{ N/mm}^2 \\ S &= 7006. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

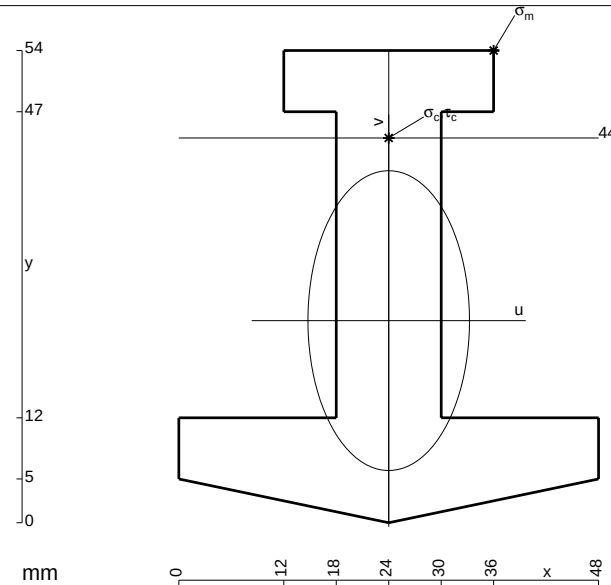
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

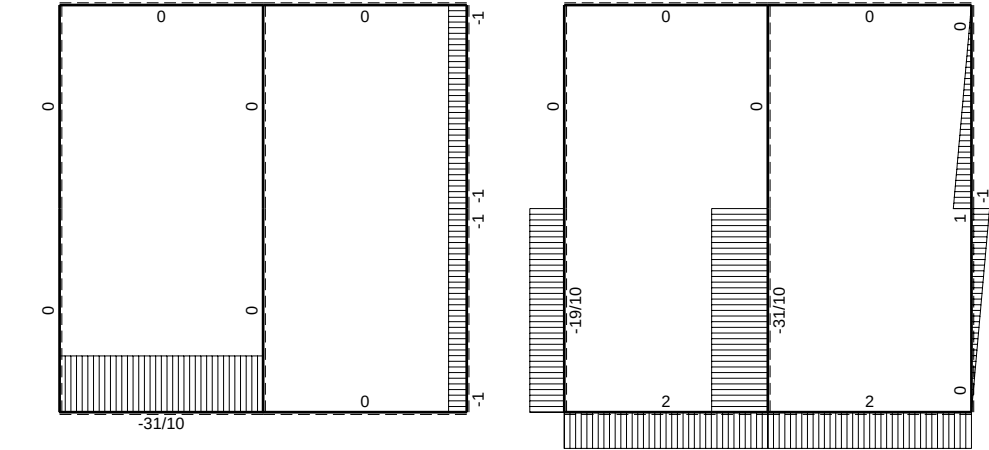
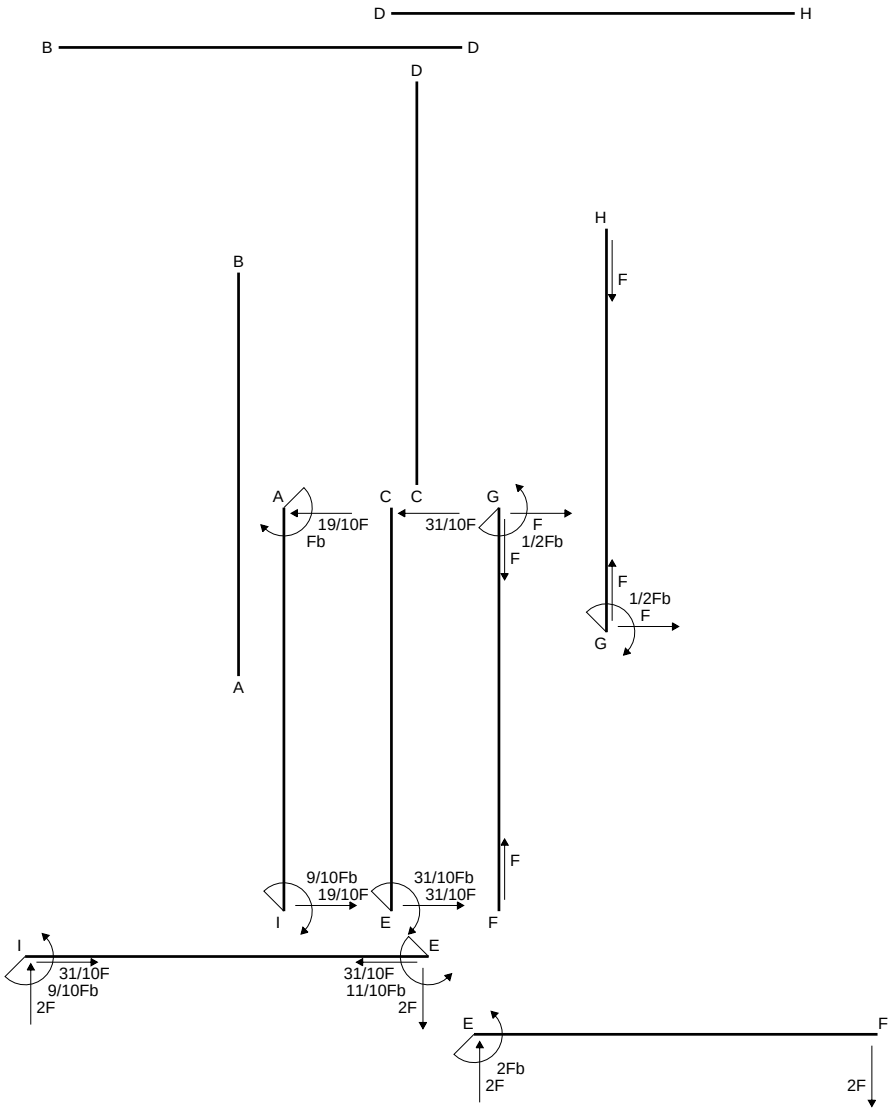
$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

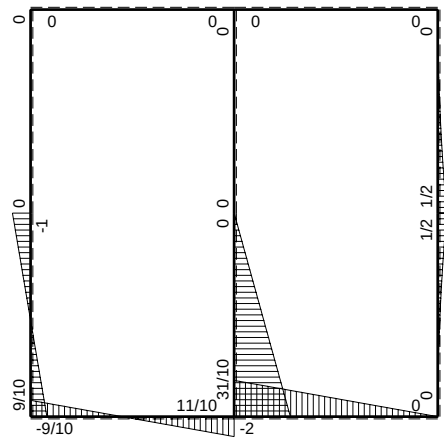


$$\begin{aligned} A &= 1044. \text{ mm}^2 \\ J_u &= 306939. \text{ mm}^4 \\ J_v &= 89136. \text{ mm}^4 \\ y_g &= 23.11 \text{ mm} \\ T_y &= 3400. \text{ N} \\ M_x &= -2176000. \text{ Nmm} \\ x_m &= 36. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 30.89 \text{ mm} \\ \sigma_m &= -Mv/J_u = 219. \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 44. \text{ mm} \\ v_c &= 20.89 \text{ mm} \\ \sigma_c &= -Mv/J_u = 148.1 \text{ N/mm}^2 \\ \tau_c &= 4.991 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 148.3 \text{ N/mm}^2 \\ S &= 5407. \text{ mm}^3 \end{aligned}$$

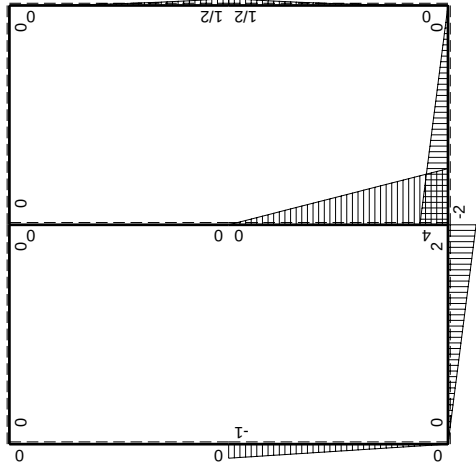
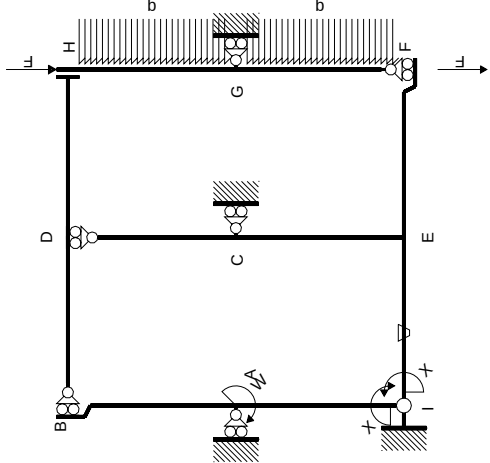


← ⊕ → F

↑ ⊕ ↓ F

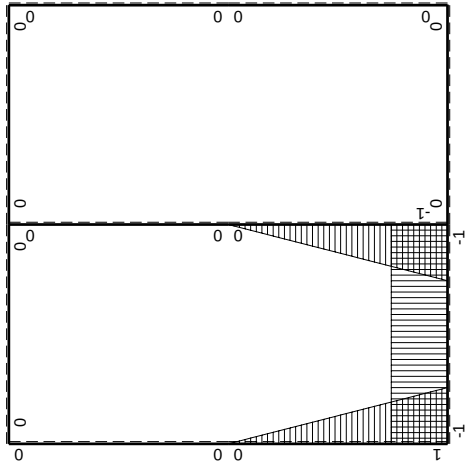


⊕ ⊖ F_b



Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati

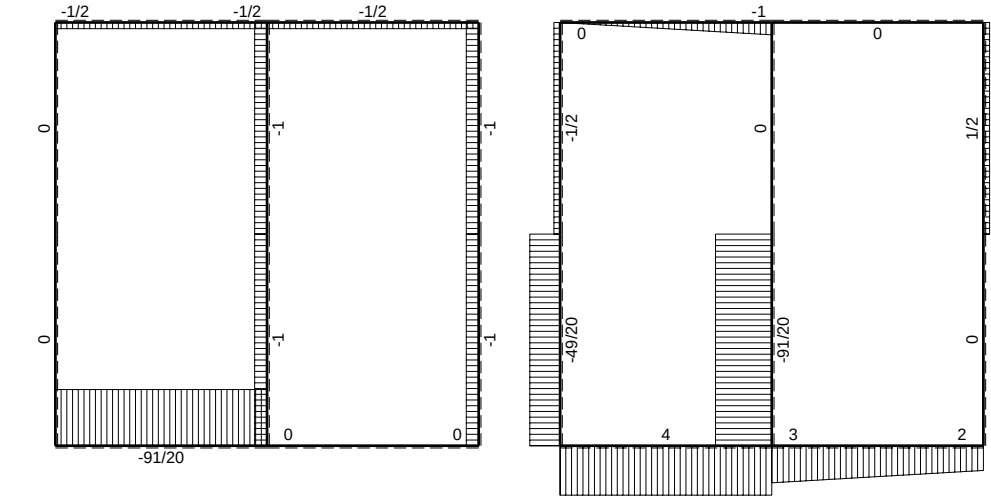
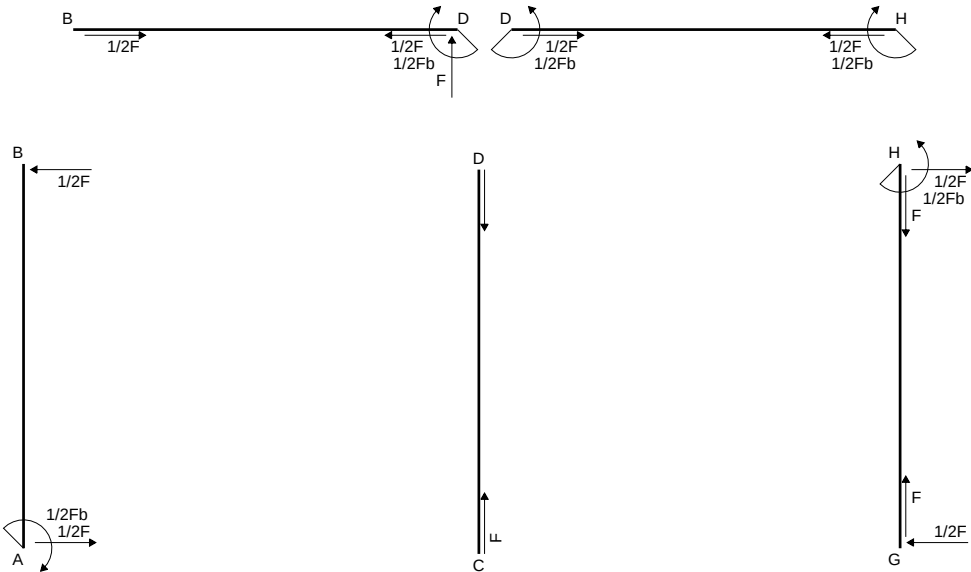


 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

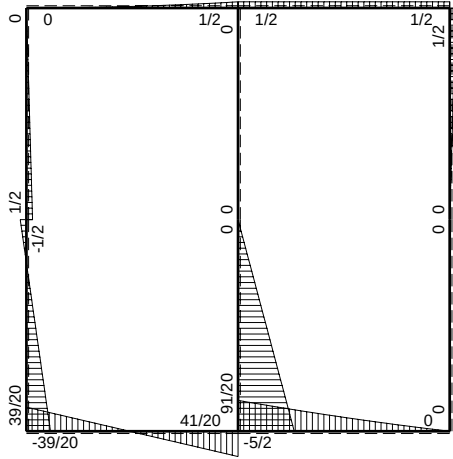
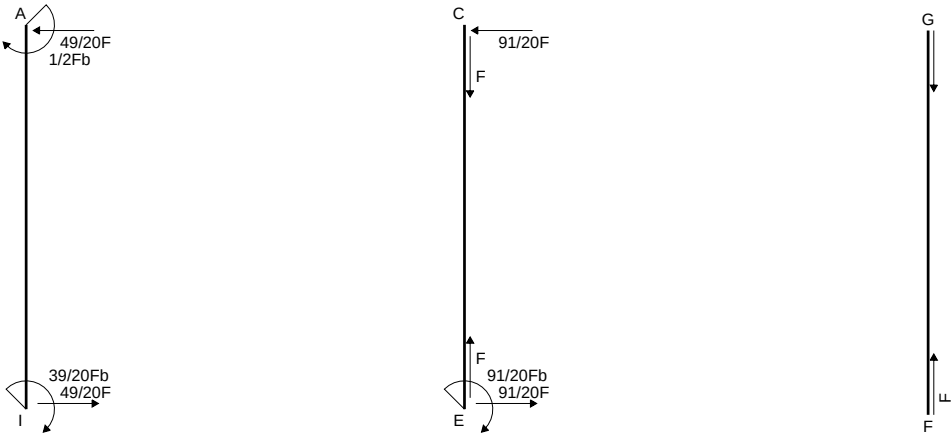
→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$-1/2qx^2$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

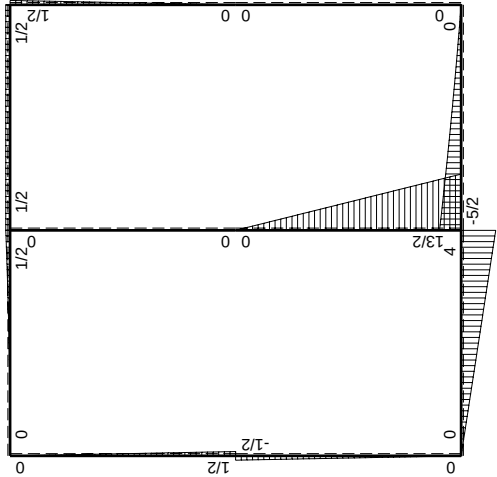
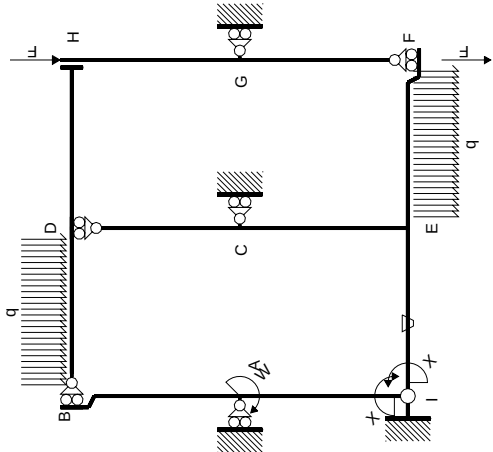


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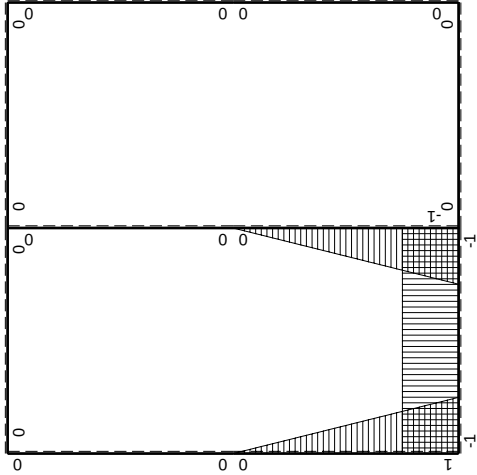


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$1/2 Fb - 1/2 Fx$	0	0	0	0	0+0	0
BA b	0	$-1/2 Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2 Fb + 3Fx - 1/2 qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx + 1/2 qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$1/2 Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2 Fb + 1/2 Fx$	0	0	0	0		
HD b	0	$1/2 Fb$	0	0	0	0	0+0	0
DH b	0	$-1/2 Fb$	0	0	0	0		
DB b	0	$1/2 Fb - Fx + 1/2 qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2 qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2 Fb - 13/2 Fx$	0	$-13/2 Fb + 13Fx - 13/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3 Xb/EJ$
CE b	x/b	$-13/2 Fx$	0	$-13/2 Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-1/2 Fx$	0	$-1/2 Fx + 1/2 Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/12+0)Fb^2/EJ$	$1/3 Xb/EJ$
AI b	$-x/b$	$1/2 Fb - 1/2 Fx$	0	$-1/2 Fx + 1/2 Fx^2/b$	0	x^2/b^2		
	totali						$-13/4 Fb^2/EJ$	$5/3 Xb/EJ$
	iperstatica $X=W_{IE}$						$39/20 Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

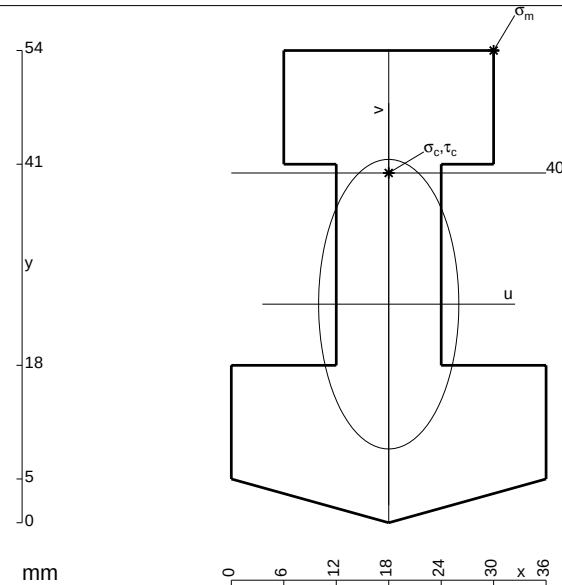
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

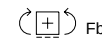
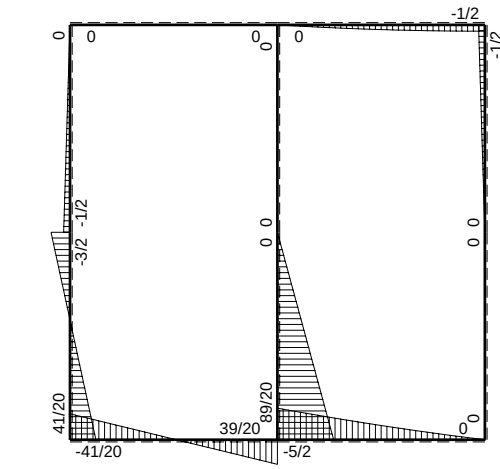
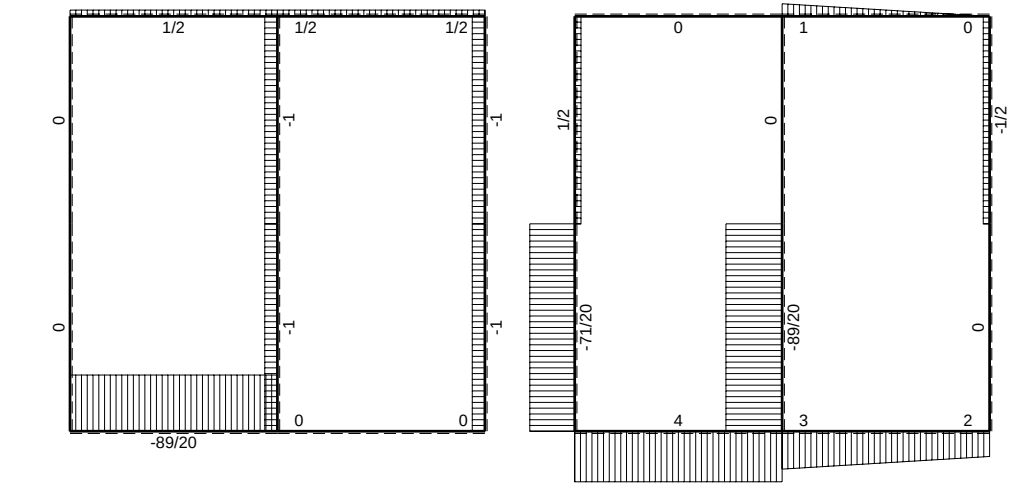
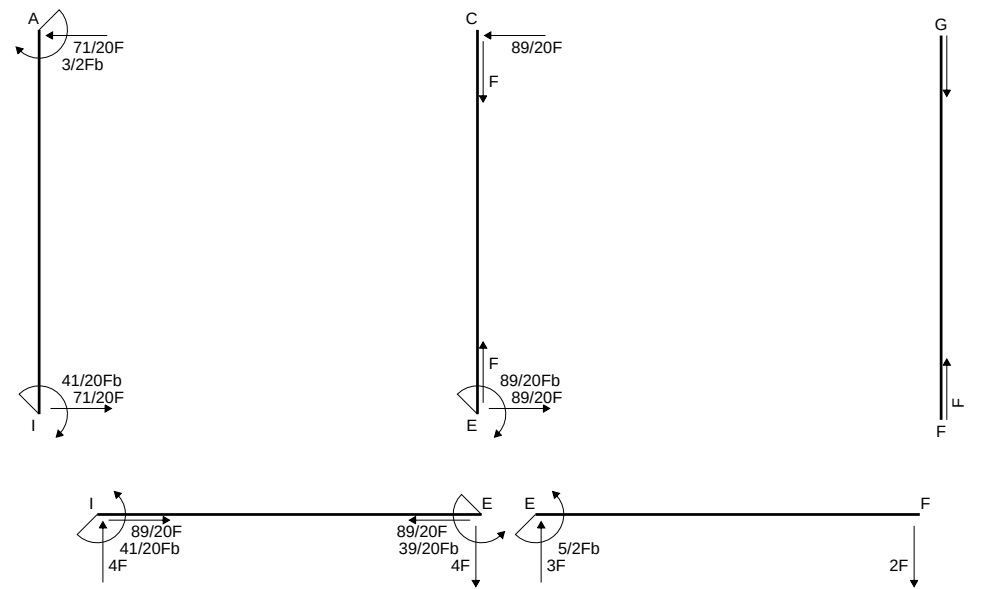
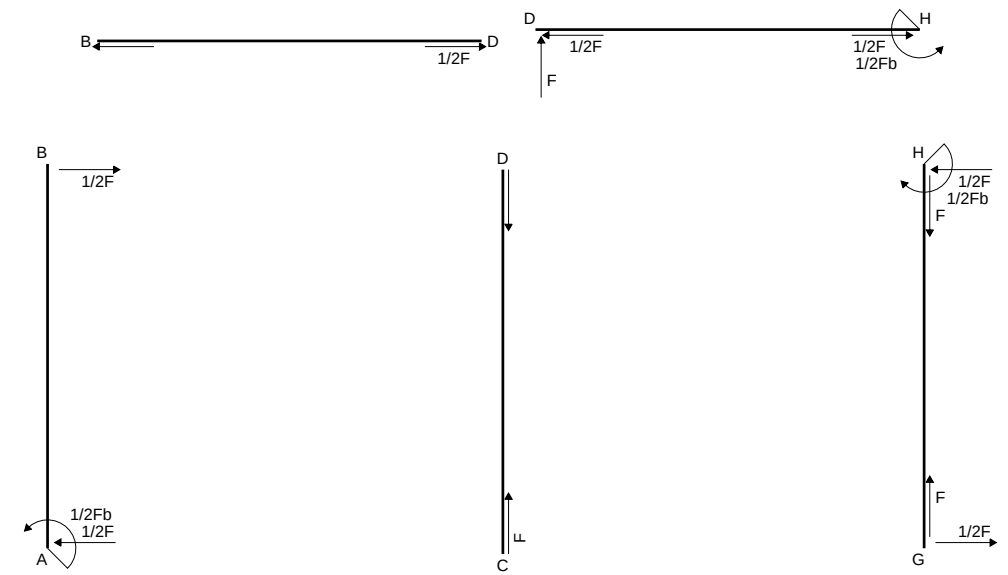
$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$

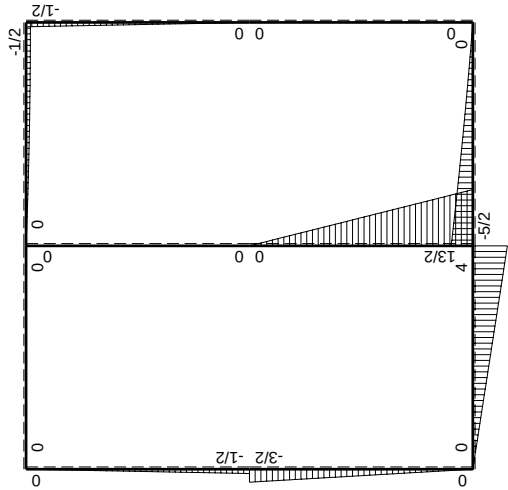
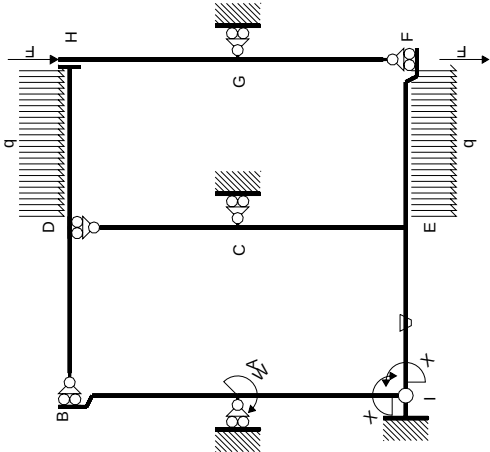
$$L_{AI}^{xo} = \int_0^b (-1/2 x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/4 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/4 b + 1/6 b) Fb \frac{1}{EJ} = -1/12 Fb^2/EJ$$



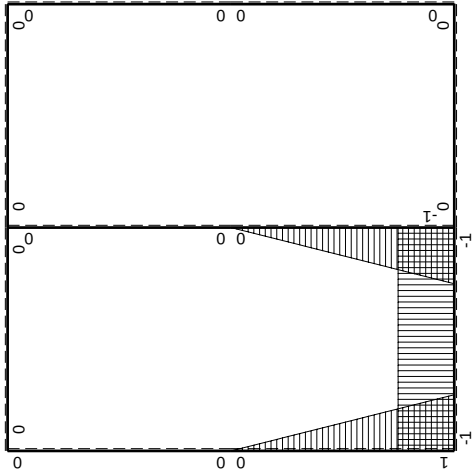
$$\begin{aligned} A &= 1146. \text{ mm}^2 \\ J_u &= 314359. \text{ mm}^4 \\ J_v &= 73692. \text{ mm}^4 \\ y_g &= 24.99 \text{ mm} \\ T_y &= 4140. \text{ N} \\ M_x &= -2587500. \text{ Nmm} \\ x_m &= 30. \text{ mm} \\ y_m &= 54. \text{ mm} \\ u_m &= 12. \text{ mm} \\ v_m &= 29.01 \text{ mm} \\ \sigma_m &= -Mv/J_u = 238.7 \text{ N/mm}^2 \\ x_c &= 18. \text{ mm} \\ y_c &= 40. \text{ mm} \\ v_c &= 15.01 \text{ mm} \\ \sigma_c &= -Mv/J_u = 123.5 \text{ N/mm}^2 \\ \tau_c &= 7.91 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 124.3 \text{ N/mm}^2 \\ S &= 7208. \text{ mm}^3 \end{aligned}$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-41/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$41/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

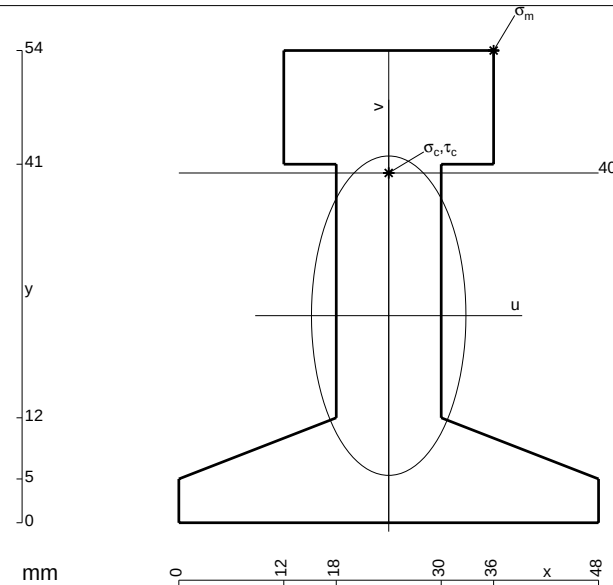
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 1110. \text{ mm}^2$$

$$J_u = 370450. \text{ mm}^4$$

$$J_v = 86652. \text{ mm}^4$$

$$y_g = 23.68 \text{ mm}$$

$$T_y = 3600. \text{ N}$$

$$M_x = -2430000. \text{ Nmm}$$

$$x_m = 36. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 12. \text{ mm}$$

$$v_m = 30.32 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 198.9 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 40. \text{ mm}$$

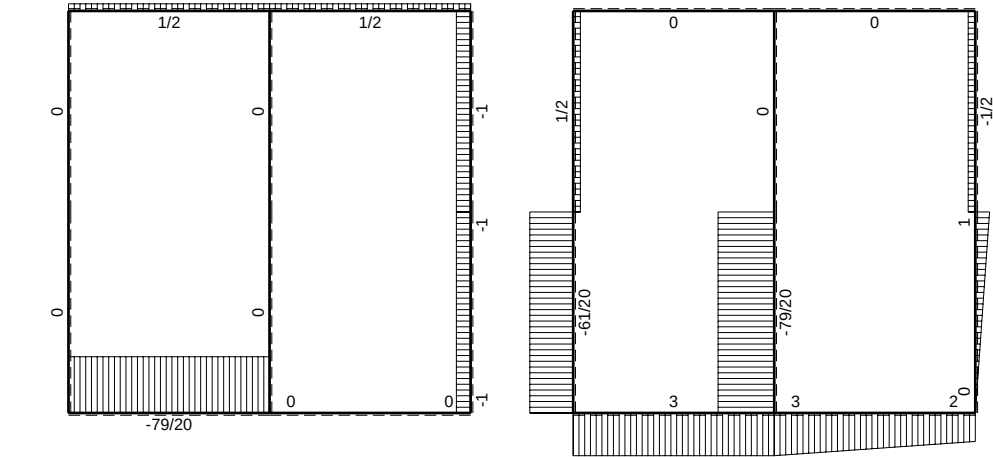
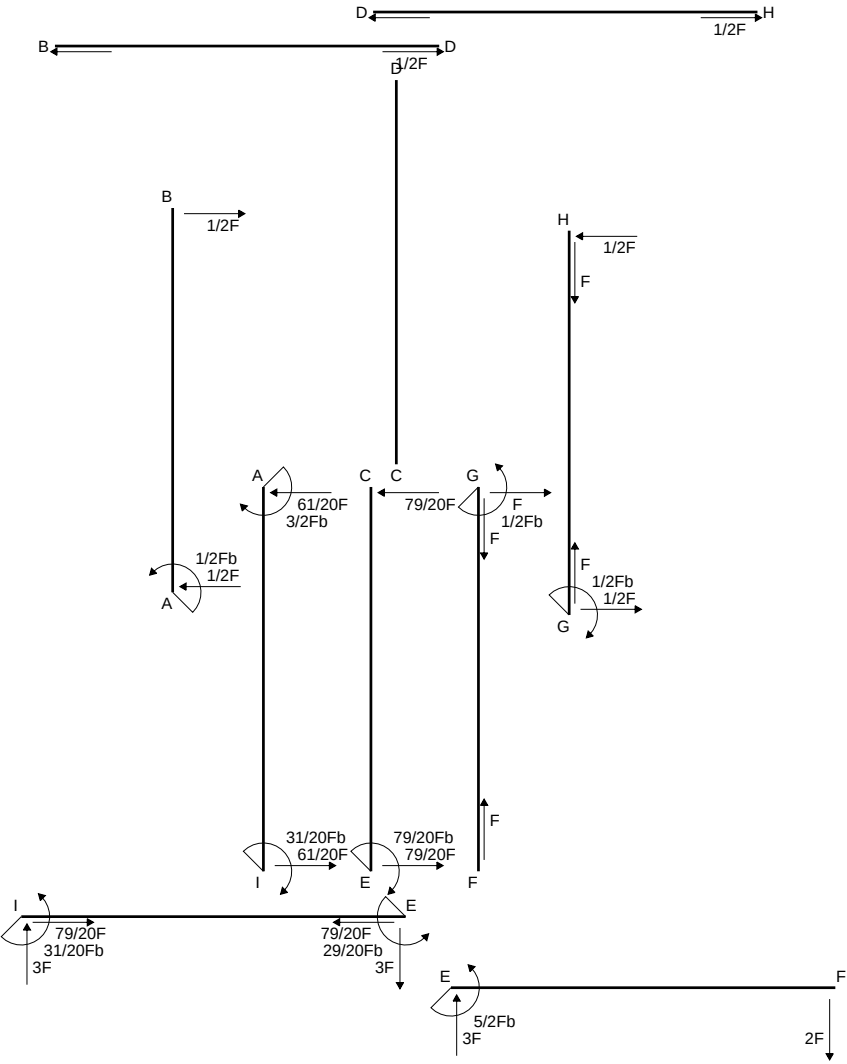
$$v_c = 16.32 \text{ mm}$$

$$\sigma_c = -Mv/J_u = 107.1 \text{ N/mm}^2$$

$$\tau_c = 6.183 \text{ N/mm}^2$$

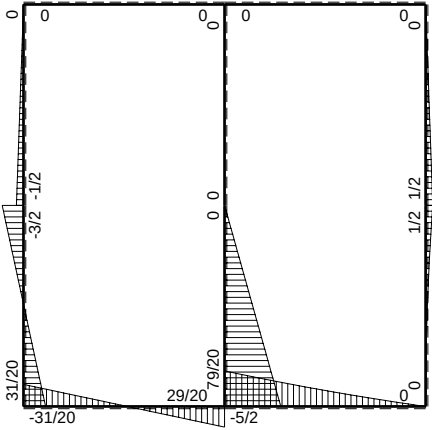
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 107.6 \text{ N/mm}^2$$

$$S = 7635. \text{ mm}^3$$

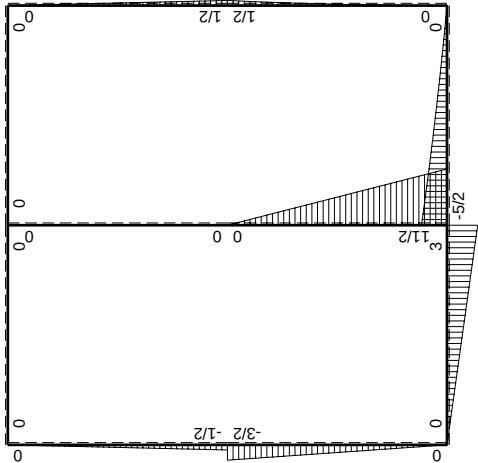
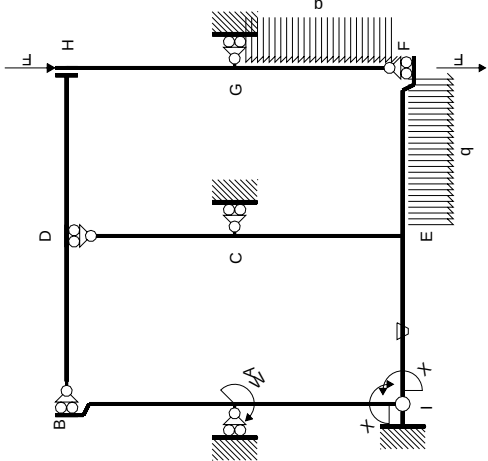


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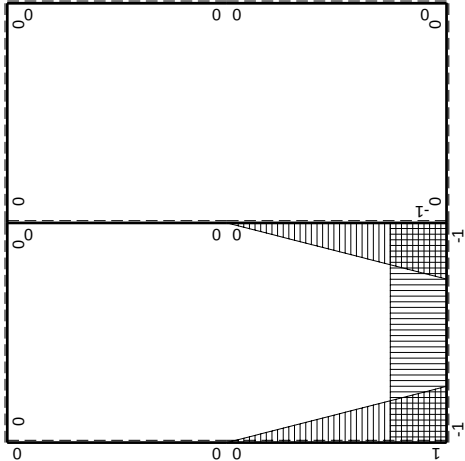


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Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-31/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$31/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

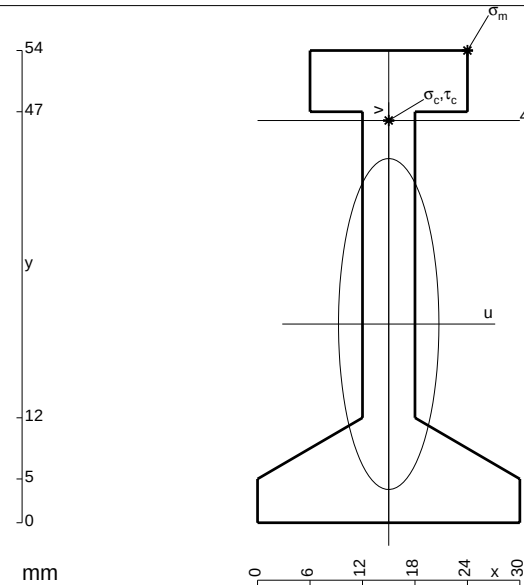
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 612. \text{ mm}^2$$

$$J_u = 219263. \text{ mm}^4$$

$$J_v = 20196. \text{ mm}^4$$

$$y_g = 22.72 \text{ mm}$$

$$T_y = 2040. \text{ N}$$

$$M_x = -1462000. \text{ Nmm}$$

$$x_m = 24. \text{ mm}$$

$$y_m = 54. \text{ mm}$$

$$u_m = 9. \text{ mm}$$

$$v_m = 31.28 \text{ mm}$$

$$\sigma_m = -Mv/J_u = 208.6 \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 46. \text{ mm}$$

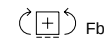
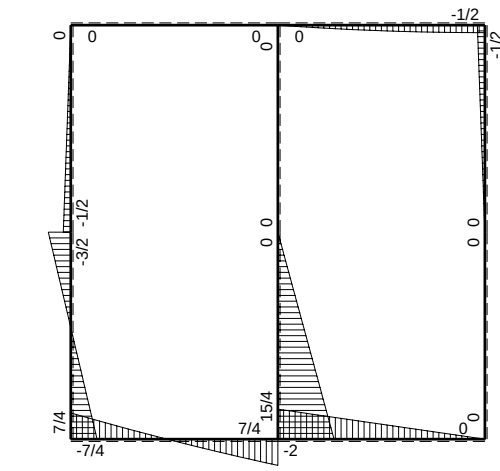
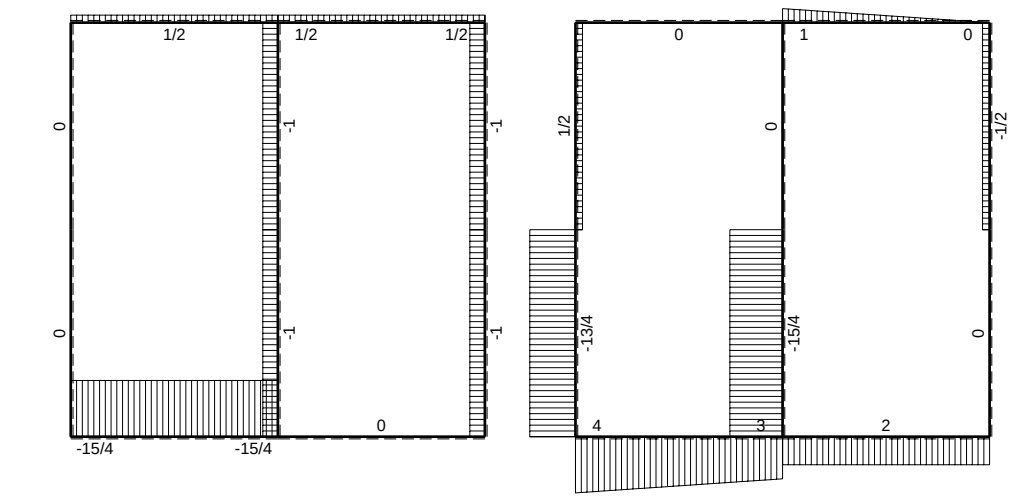
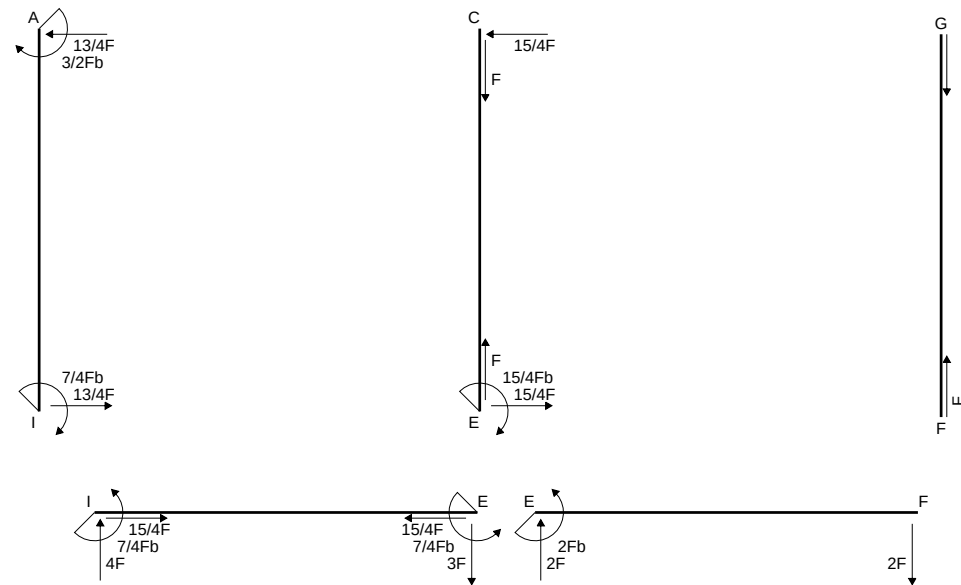
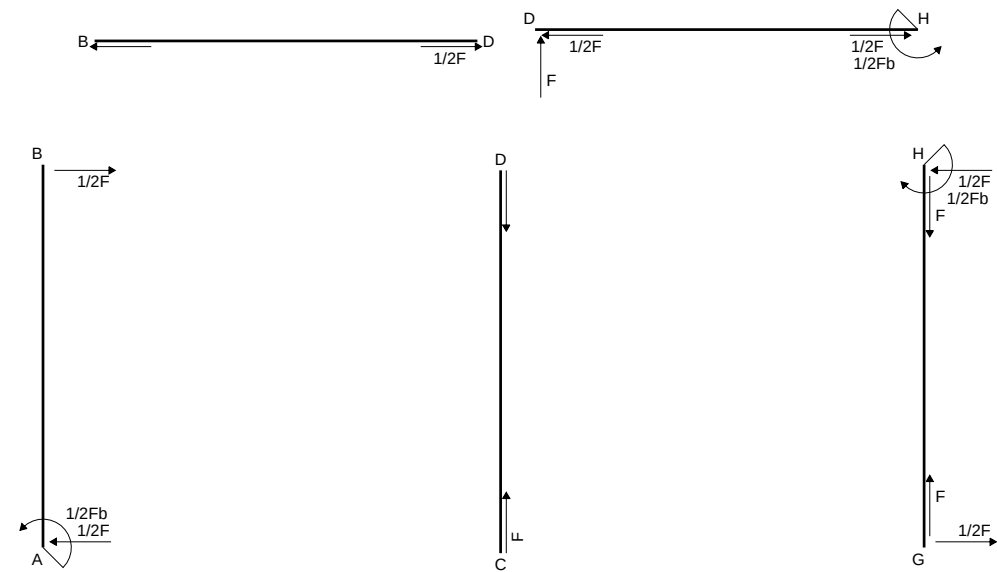
$$v_c = 23.28 \text{ mm}$$

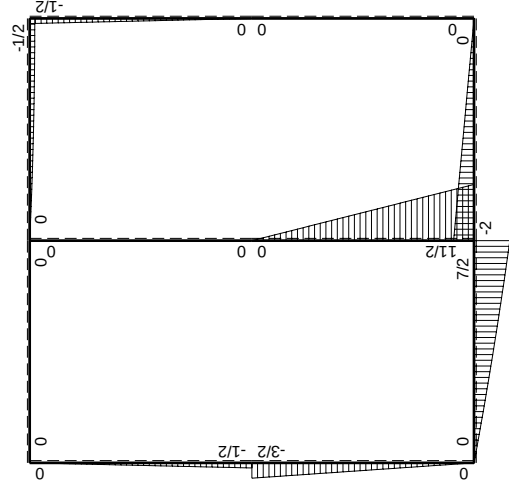
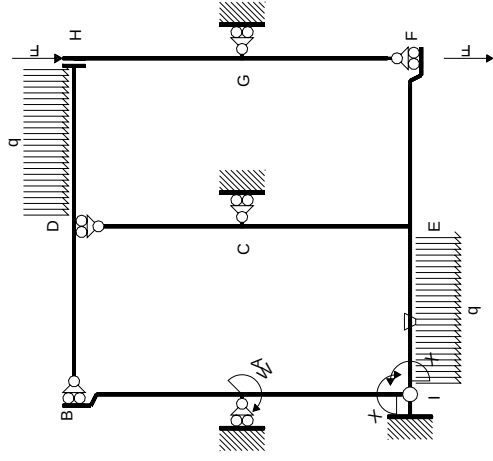
$$\sigma_c = -Mv/J_u = 155.2 \text{ N/mm}^2$$

$$\tau_c = 5.648 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 155.5 \text{ N/mm}^2$$

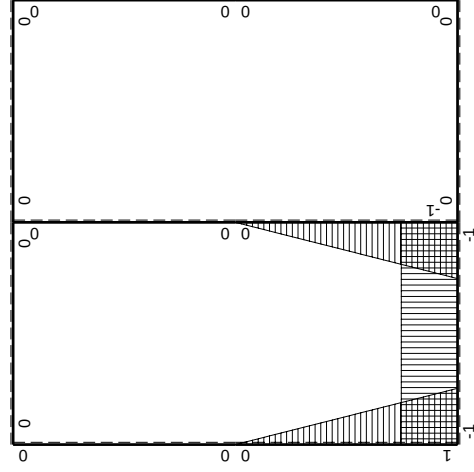
$$S = 3643. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx-1/2qx^2$	$-Fb/EJ$	$-4Fx+1/2Fx^2/b$	Fb/EJ	1	$(-11/6+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-7/2Fb+3Fx+1/2qx^2$	Fb/EJ	$-7/2Fb+3Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$11/2Fb-11/2Fx$	0	$-11/2Fb+11Fx-11/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-11/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-11/2Fx$	0	$-11/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-35/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -5/6 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-7/2 + 3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-7/2 x + 3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-7/2 b + 3/2 b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -5/6 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-11/2 + 11x/b - 11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/2 x + 11/2 x^2/b - 11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-11/2 b + 11/2 b - 11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-11/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-11/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

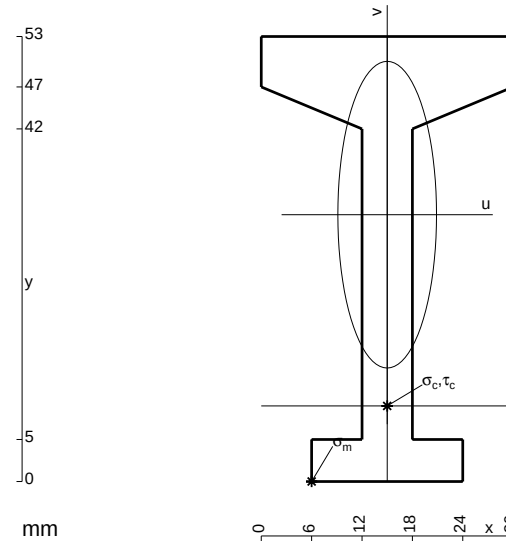
$$= (-11/6 b) Fb \frac{1}{EJ} = -11/6 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 582. \text{ mm}^2$$

$$J_u = 194208. \text{ mm}^4$$

$$J_v = 20106. \text{ mm}^4$$

$$y_g = 31.78 \text{ mm}$$

$$T_y = 1480. \text{ N}$$

$$M_x = -1332000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -31.78 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -218. \text{ N/mm}^2$$

$$x_c = 15. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

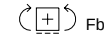
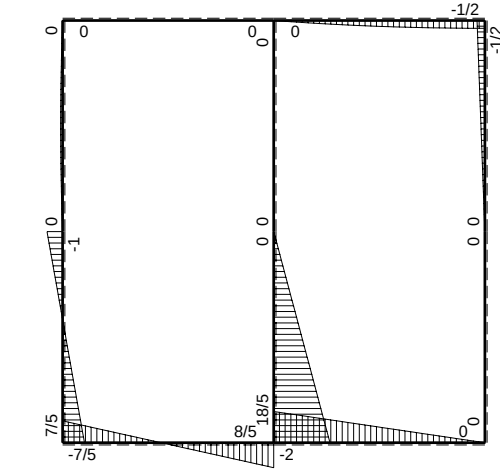
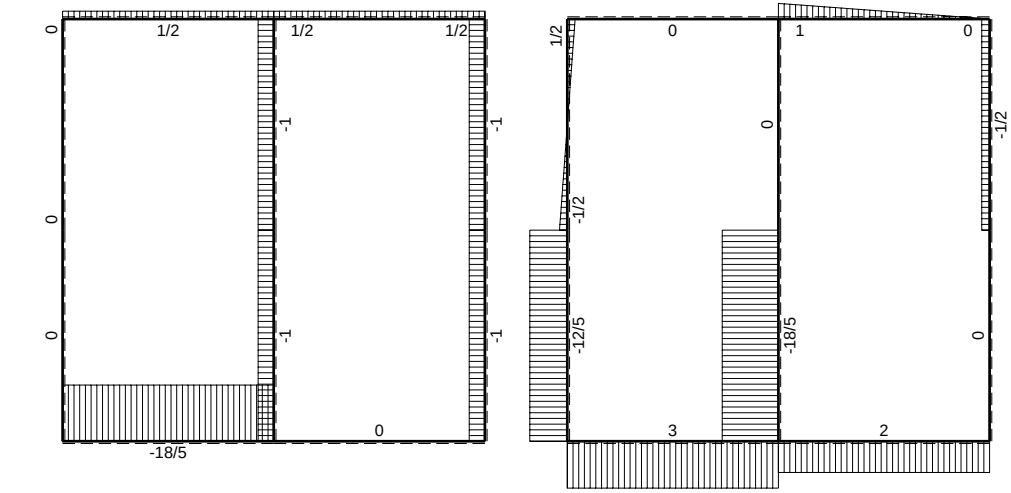
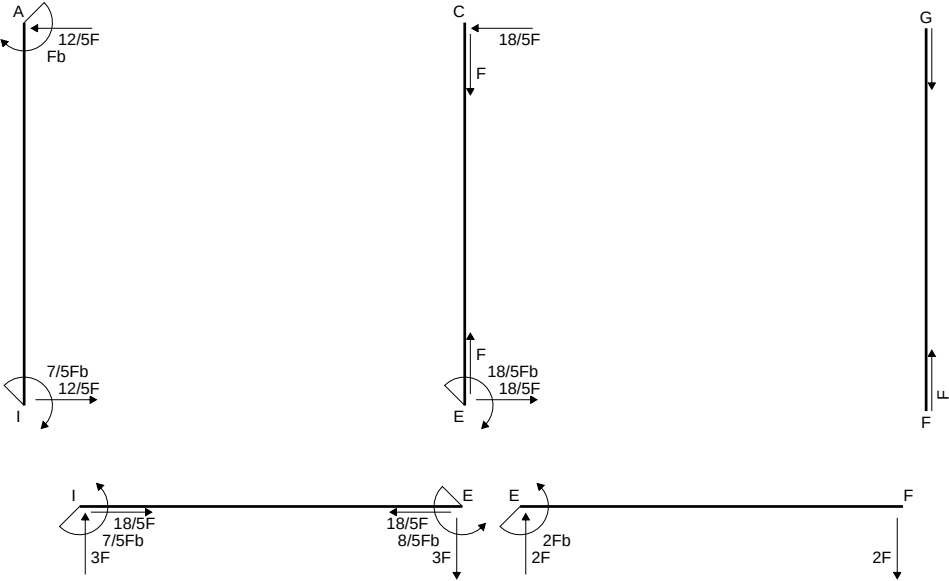
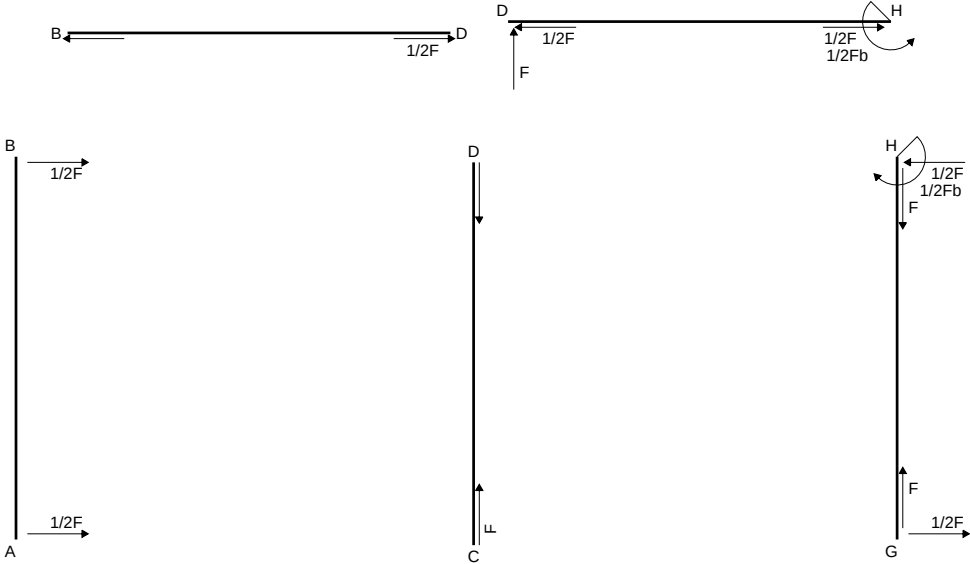
$$v_c = -22.78 \text{ mm}$$

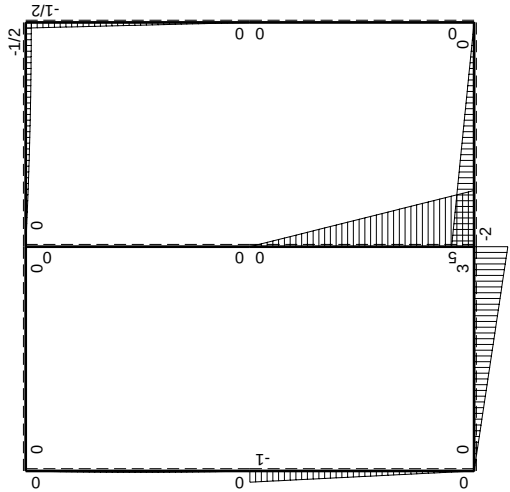
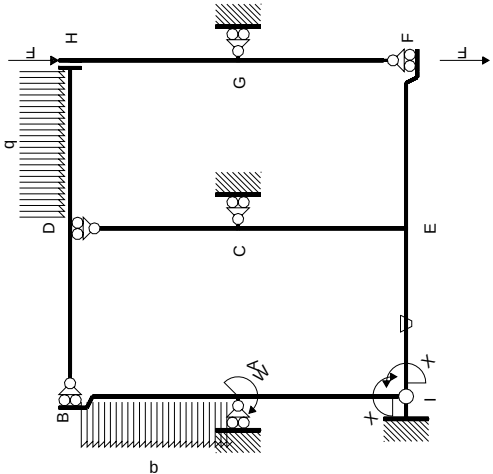
$$\sigma_c = -Mv/J_u = -156.3 \text{ N/mm}^2$$

$$\tau_c = 4.103 \text{ N/mm}^2$$

$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 156.4 \text{ N/mm}^2$$

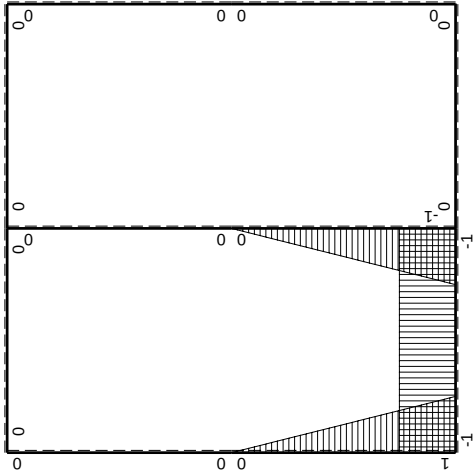
$$S = 3230. \text{ mm}^3$$





Schema di calcolo iperstatico

 M_0 flessione da carichi assegnati



 M_X flessione da iperstatica X=1

Quadro contributi PLV per iperstatica X=W_{IE}

→	M _x (x)	M _o (x)	θ	M _x M _o	M _x θ	M _x M _x	∫M _x (M _o /EJ+θ)dx	∫XM _x M _x /EJdx
AB b	0	-1/2Fx+1/2qx ²	0	0	0	0	0+0	0
BA b	0	1/2Fx-1/2qx ²	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	-1/2Fx	0	0	0	0	0+0	0
HG b	0	1/2Fb-1/2Fx	0	0	0	0		
HD b	0	-1/2Fb+1/2qx ²	0	0	0	0	0+0	0
DH b	0	Fx-1/2qx ²	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	(-3/2+1)Fb ² /EJ	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	-1+x/b	5Fb-5Fx	0	-5Fb+10Fx-5Fx ² /b	0	1-2x/b+x ² /b ²	(-5/3+0)Fb ² /EJ	1/3Xb/EJ
CE b	x/b	-5Fx	0	-5Fx ² /b	0	x ² /b ²		
IA b	1-x/b	-Fx	0	-Fx+Fx ² /b	0	1-2x/b+x ² /b ²	(-1/6+0)Fb ² /EJ	1/3Xb/EJ
AI b	-x/b	Fb-Fx	0	-Fx+Fx ² /b	0	x ² /b ²		
	totali						-7/3Fb ² /EJ	5/3Xb/EJ
	iperstatica X=W _{IE}						7/5Fb	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

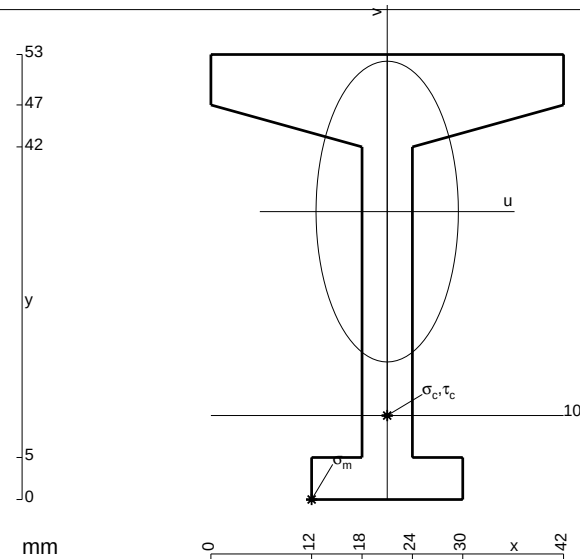
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 684. \text{ mm}^2$$

$$J_u = 219556. \text{ mm}^4$$

$$J_v = 49140. \text{ mm}^4$$

$$y_g = 34.29 \text{ mm}$$

$$T_y = 1540. \text{ N}$$

$$M_x = -1463000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -9. \text{ mm}$$

$$v_m = -34.29 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -228.5 \text{ N/mm}^2$$

$$x_c = 21. \text{ mm}$$

$$y_c = 10. \text{ mm}$$

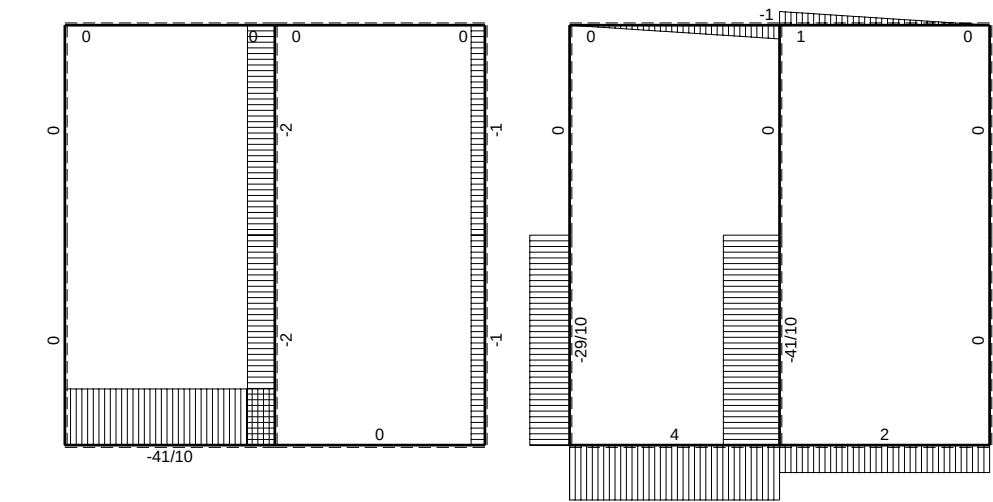
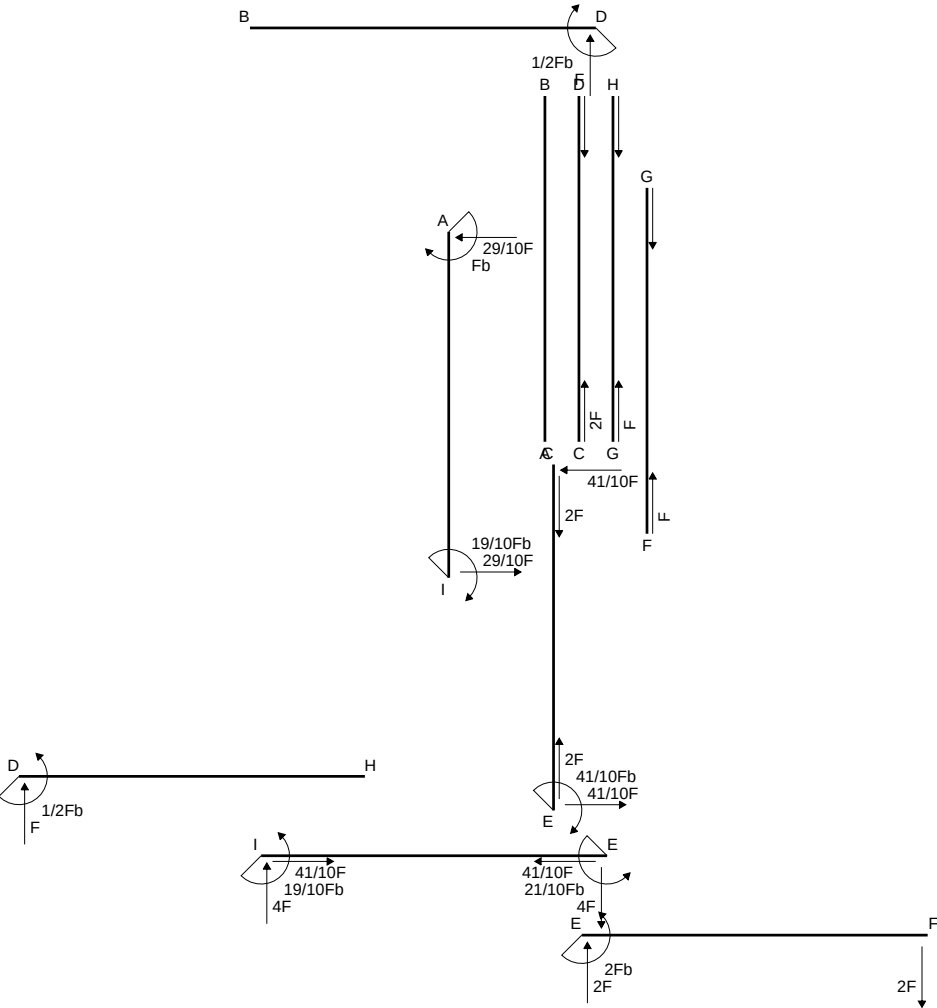
$$v_c = -24.29 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -161.9 \text{ N/mm}^2$$

$$\tau_c = 4.285 \text{ N/mm}^2$$

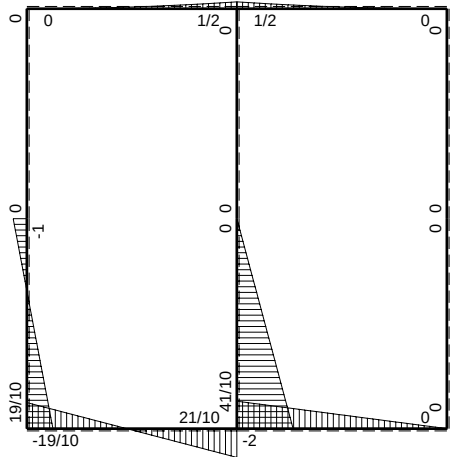
$$\sigma_o = \sqrt{\sigma^2 + 3\tau^2} = 162.1 \text{ N/mm}^2$$

$$S = 3665. \text{ mm}^3$$



← ⊕ → F

↑ ⊕ ↓ F



⊕ ⊖ F_b

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int x M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	0	0	0	0	0	0+0	0
HG b	0	0	0	0	0	0		
HD b	0	$1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
DB b	0	$1/2Fb-Fx+1/2qx^2$	0	0	0	0	0+0	0
BD b	0	$-1/2qx^2$	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$6Fb-6Fx$	0	$-6Fb+12Fx-6Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-6Fx$	0	$-6Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-19/6Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$19/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-6 + 12x/b - 6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-6x + 6x^2/b - 2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-6b + 6b - 2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-6x^2/b^2) Fb \frac{1}{EJ} dx = \left[-2x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

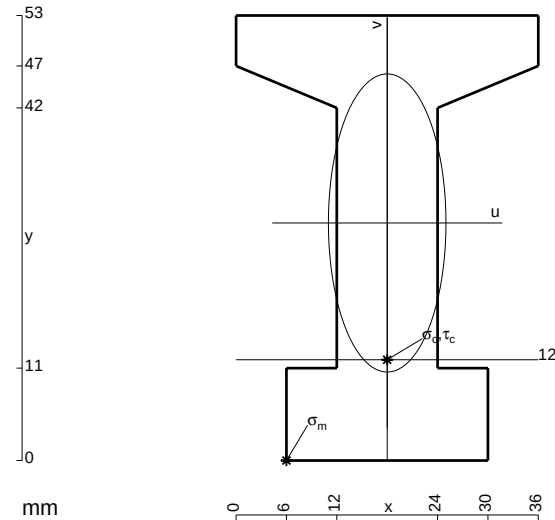
$$= (-2b) Fb \frac{1}{EJ} = -2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 972. \text{ mm}^2$$

$$J_u = 306619. \text{ mm}^4$$

$$J_v = 47664. \text{ mm}^4$$

$$y_g = 28.29 \text{ mm}$$

$$T_y = 2600. \text{ N}$$

$$M_x = -2600000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.29 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -239.9 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

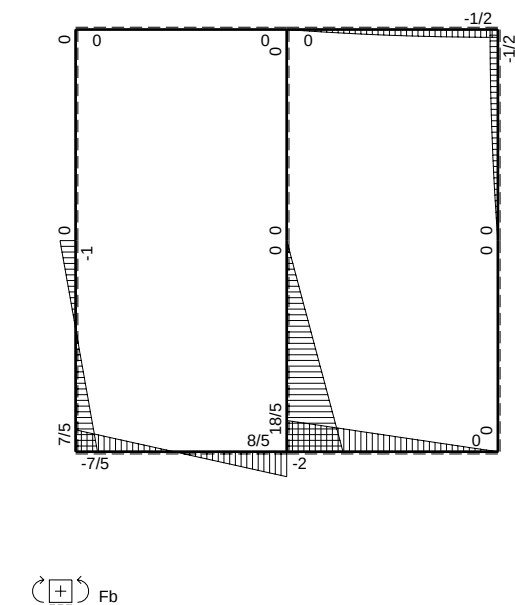
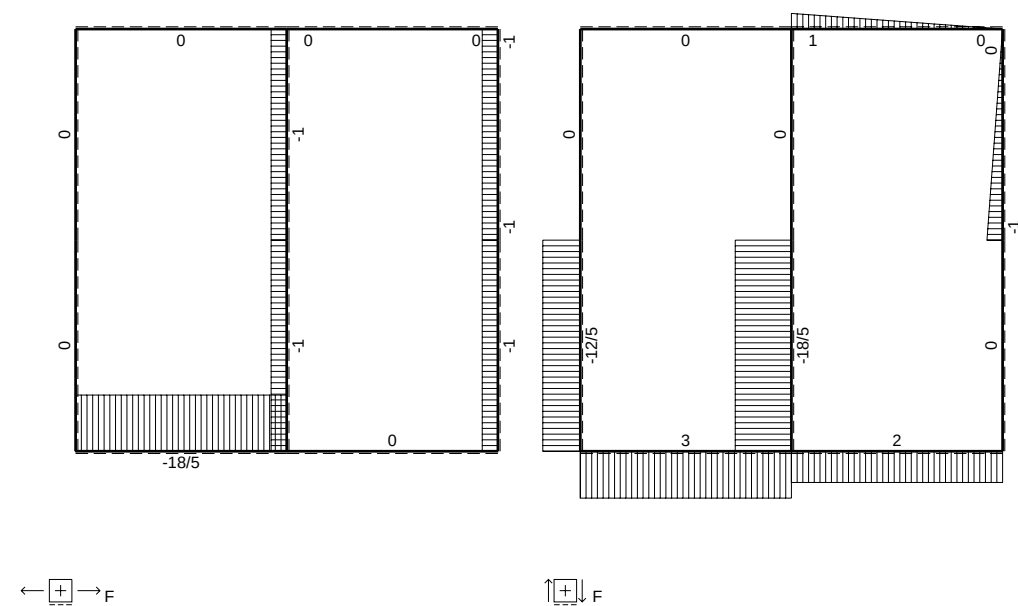
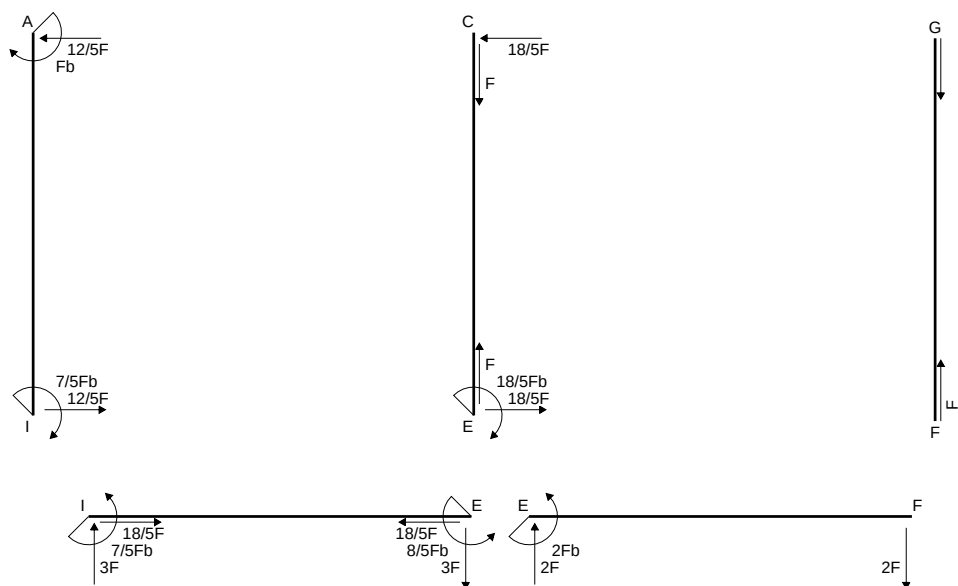
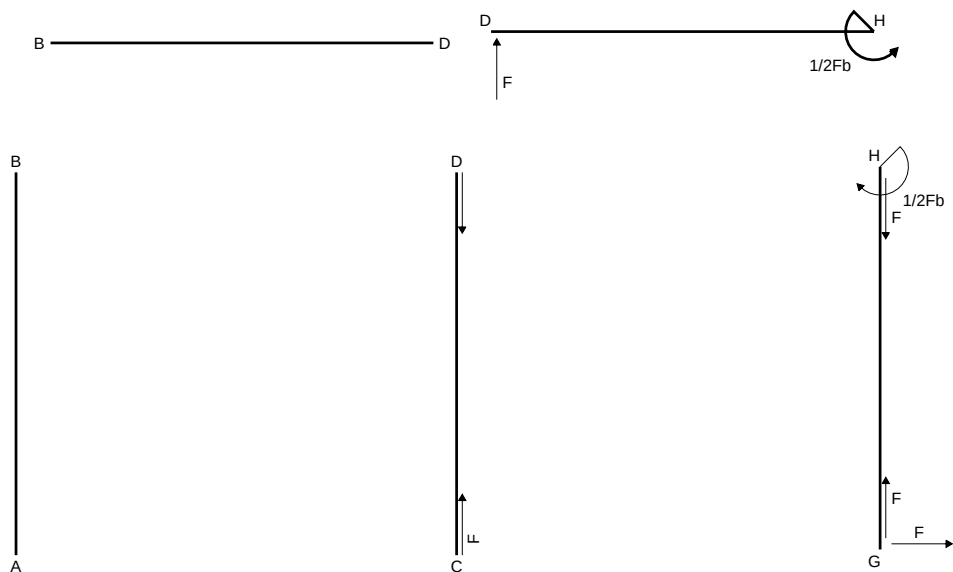
$$v_c = -16.29 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -138.2 \text{ N/mm}^2$$

$$\tau_c = 4.394 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 138.4 \text{ N/mm}^2$$

$$S = 6219. \text{ mm}^3$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	0	0	0	0	0	0+0	0
BA b	0	0	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-Fx+1/2qx^2$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2qx^2$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx$	$-Fb/EJ$	$-3Fx$	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-3Fb+3Fx$	Fb/EJ	$-3Fb+3Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-7/3Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$7/5Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x0} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{x0} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{x0} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{x0} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

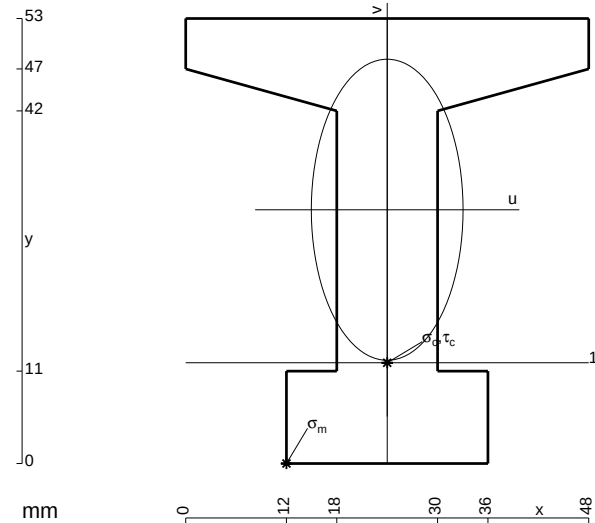
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{x0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{x0} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$A = 1074. \text{ mm}^2$$

$$J_u = 345511. \text{ mm}^4$$

$$J_v = 87732. \text{ mm}^4$$

$$y_g = 30.22 \text{ mm}$$

$$T_y = 4300. \text{ N}$$

$$M_x = -2279000. \text{ Nmm}$$

$$x_m = 12. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -30.22 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -199.4 \text{ N/mm}^2$$

$$x_c = 24. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

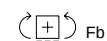
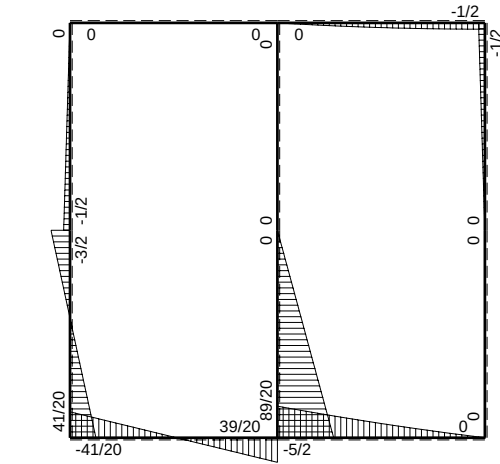
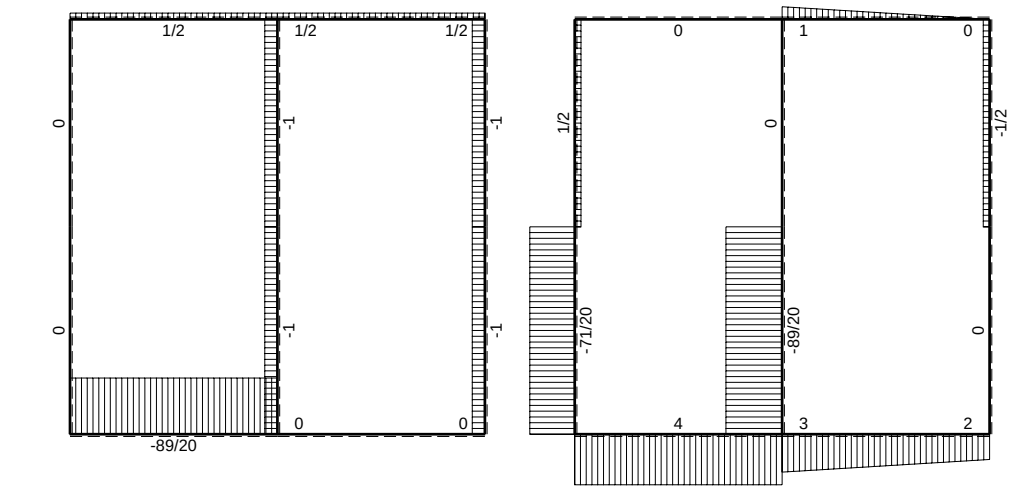
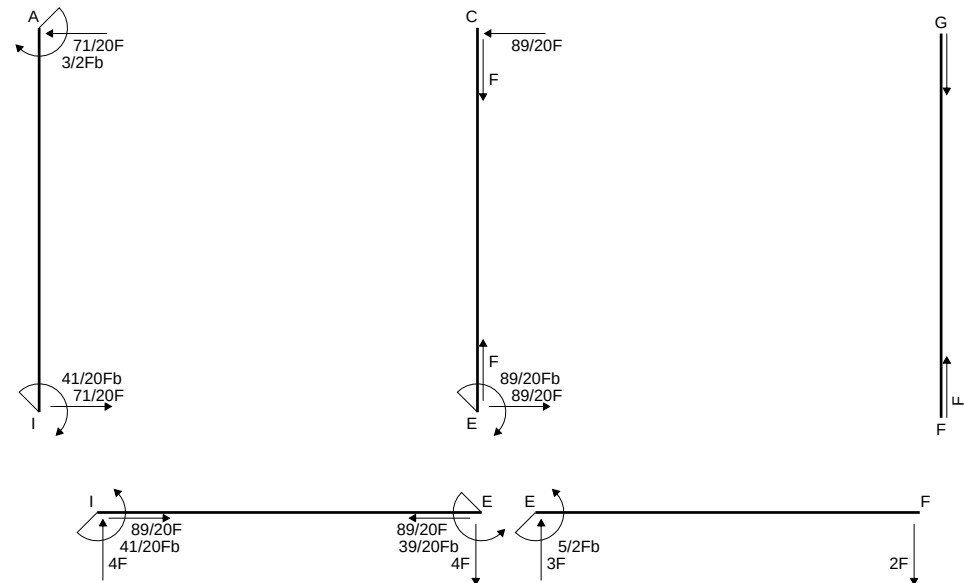
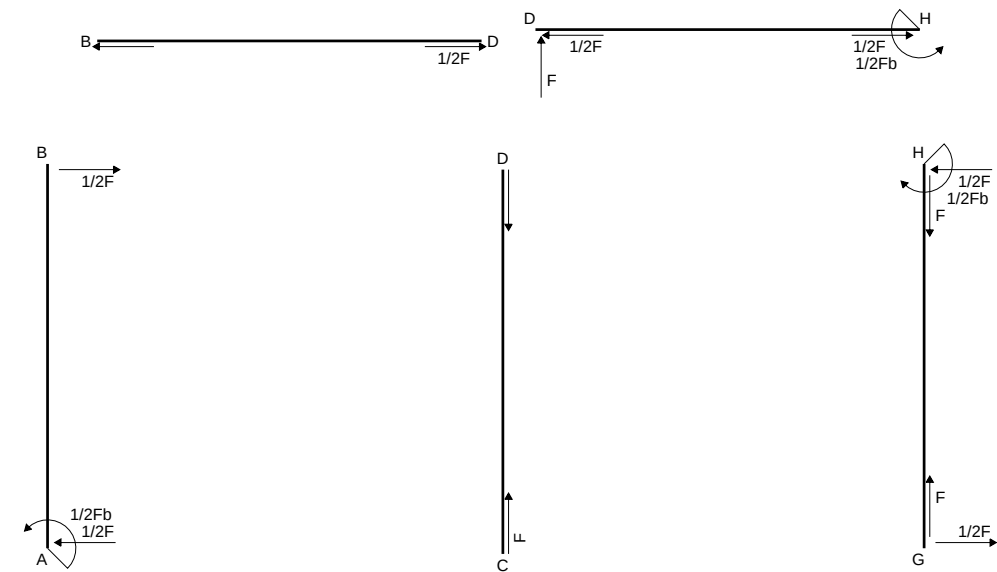
$$v_c = -18.22 \text{ mm}$$

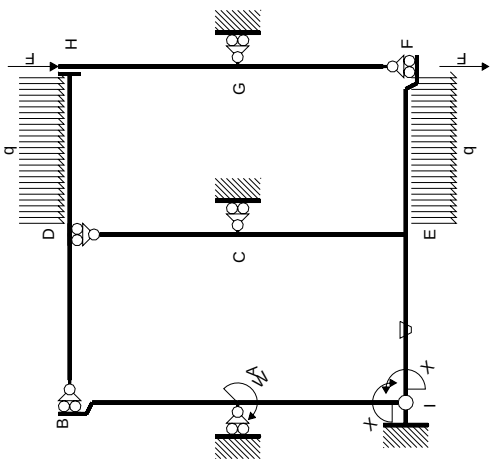
$$\sigma_c = -Mv/J_u = -120.2 \text{ N/mm}^2$$

$$\tau_c = 7.002 \text{ N/mm}^2$$

$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 120.8 \text{ N/mm}^2$$

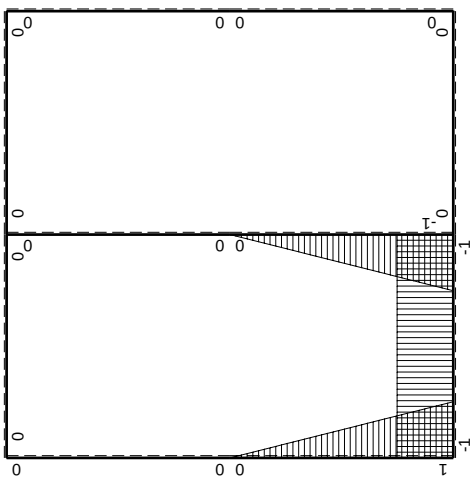
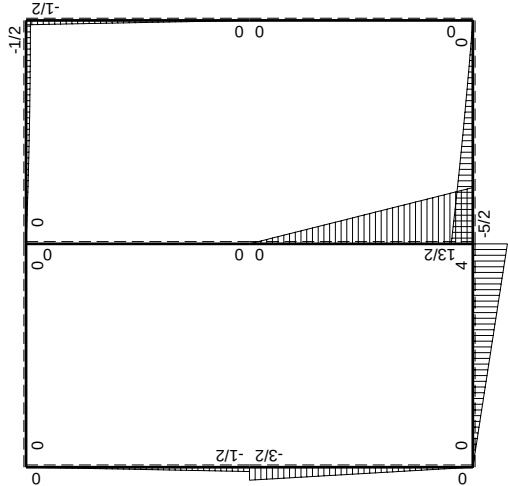
$$S = 6752. \text{ mm}^3$$





Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-5/2Fb+3Fx-1/2qx^2$	0	0	0	0	0+0	0
FE b	0	$2Fx+1/2qx^2$	0	0	0	0		
FG b	0	0	0	0	0	0	0+0	0
GF b	0	0	0	0	0	0		
GH b	0	$-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-1/2Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$4Fx$	$-Fb/EJ$	$-4Fx$	Fb/EJ	1	$(-2+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-4Fb+4Fx$	Fb/EJ	$-4Fb+4Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$13/2Fb-13/2Fx$	0	$-13/2Fb+13Fx-13/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-13/6+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-13/2Fx$	0	$-13/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-41/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$41/20Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{x\theta} = \int_0^b (-4x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-2b) Fb \frac{1}{EJ} + (b) \theta = -Fb^2/EJ$$

$$L_{EI}^{x\theta} = \int_0^b (-4 + 4x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-4x + 2x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-4b + 2b) Fb \frac{1}{EJ} + (-b) \theta = -Fb^2/EJ$$

$$L_{EC}^{x\theta} = \int_0^b (-13/2 + 13x/b - 13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/2 x + 13/2 x^2/b - 13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-13/2 b + 13/2 b - 13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{CE}^{x\theta} = \int_0^b (-13/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-13/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

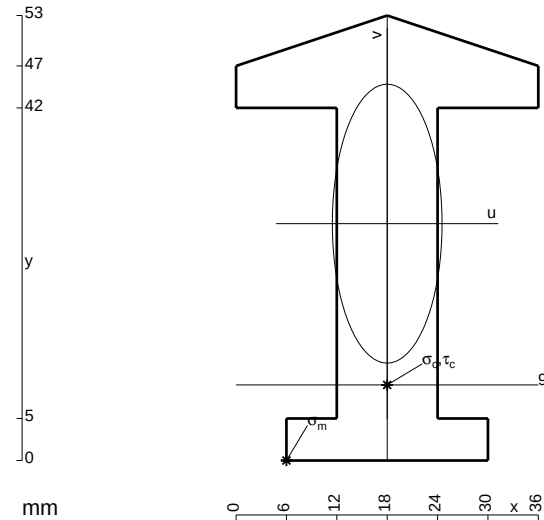
$$= (-13/6 b) Fb \frac{1}{EJ} = -13/6 Fb^2/EJ$$

$$L_{IA}^{x\theta} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{x\theta} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 852. \text{ mm}^2$$

$$J_u = 235110. \text{ mm}^4$$

$$J_v = 36360. \text{ mm}^4$$

$$y_g = 28.21 \text{ mm}$$

$$T_y = 3600. \text{ N}$$

$$M_x = -1740000. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.21 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -208.8 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 9. \text{ mm}$$

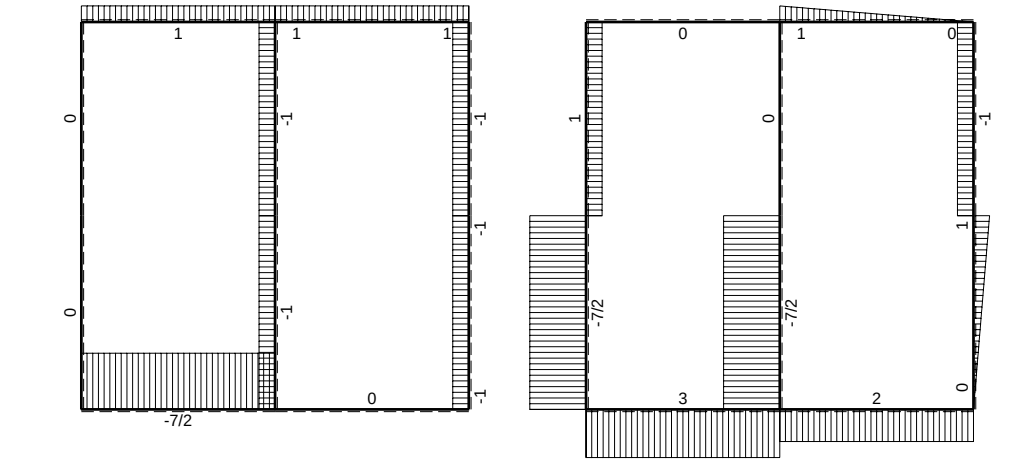
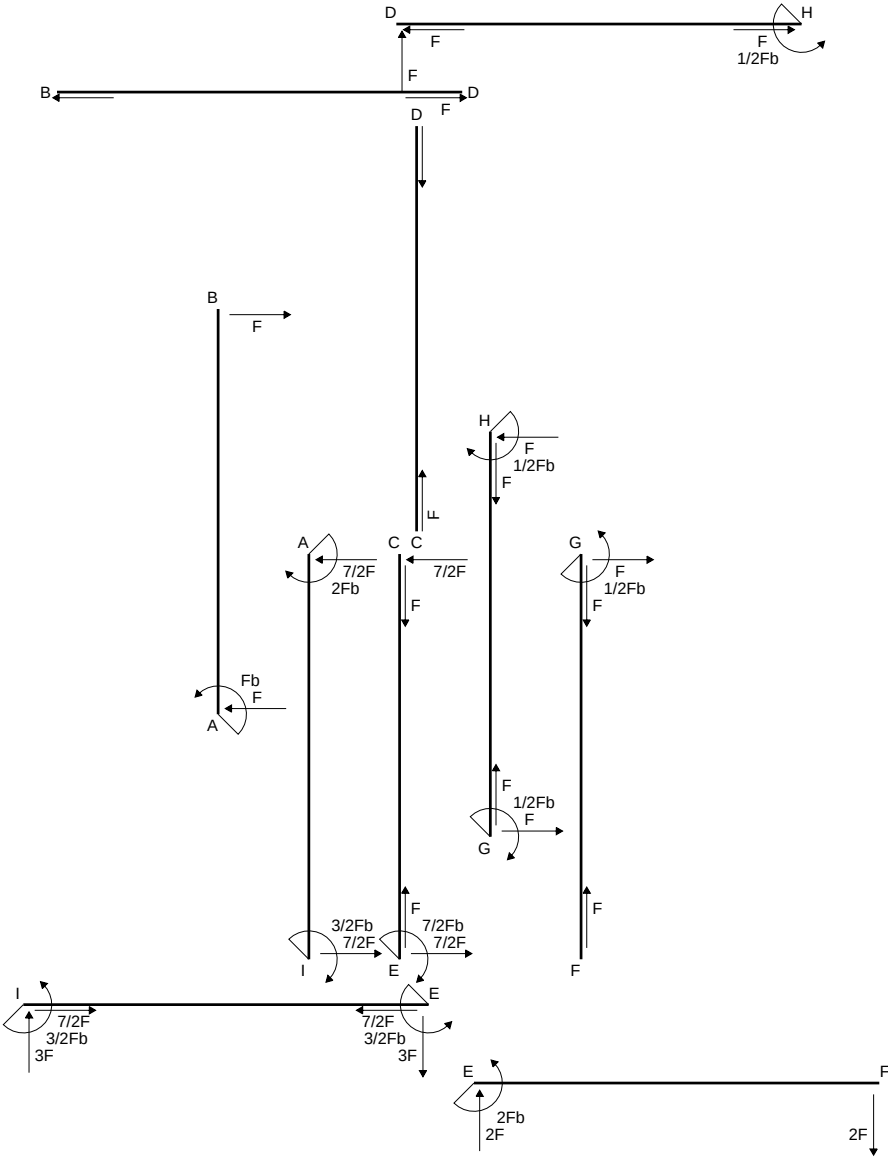
$$v_c = -19.21 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -142.2 \text{ N/mm}^2$$

$$\tau_c = 5.236 \text{ N/mm}^2$$

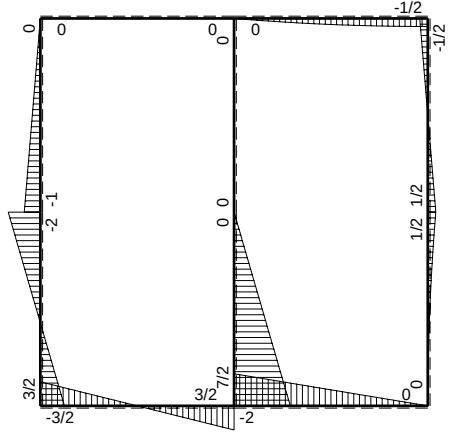
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 142.5 \text{ N/mm}^2$$

$$S = 4103. \text{ mm}^3$$

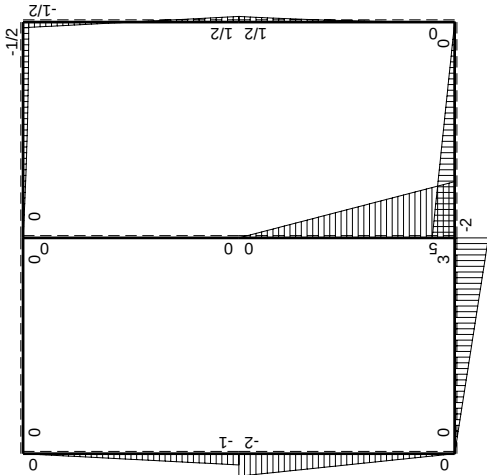
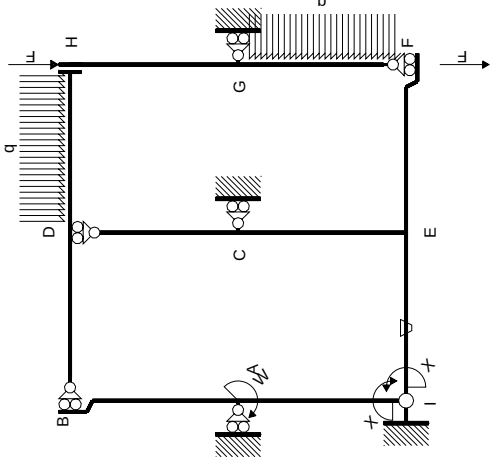


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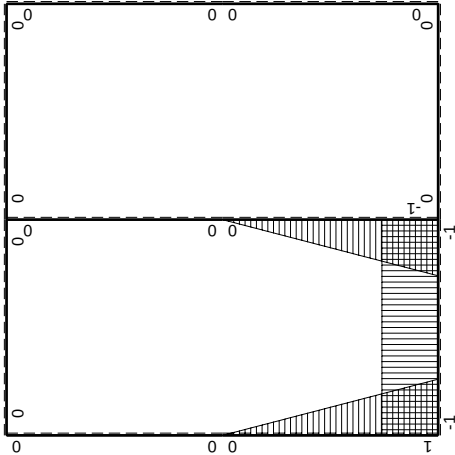


⊕ ⊖ Fb



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica X=1

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	-Fb+Fx	0	0	0	0	0+0	0
BA b	0	Fx	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	-2Fb+2Fx	0	0	0	0	0+0	0
FE b	0	2Fx	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-Fx$	0	0	0	0	0+0	0
HG b	0	$1/2Fb-Fx$	0	0	0	0		
HD b	0	$-1/2Fb+1/2qx^2$	0	0	0	0	0+0	0
DH b	0	$Fx-1/2qx^2$	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	3Fx	-Fb/EJ	-3Fx	Fb/EJ	1	$(-3/2+1)Fb^2/EJ$	Xb/EJ
EI b	1	-3Fb+3Fx	Fb/EJ	-3Fb+3Fx	Fb/EJ	1		
EC b	$-1+x/b$	$5Fb-5Fx$	0	$-5Fb+10Fx-5Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-5/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-5Fx$	0	$-5Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-2Fx$	0	$-2Fx+2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/3+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$2Fb-2Fx$	0	$-2Fx+2Fx^2/b$	0	x^2/b^2		
	totali						$-5/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$3/2Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b) Fb \frac{1}{EJ} + (b) \theta = -1/2 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-3 + 3x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-3x + 3/2 x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-3b + 3/2 b) Fb \frac{1}{EJ} + (-b) \theta = -1/2 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-5 + 10x/b - 5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5x + 5x^2/b - 5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-5b + 5b - 5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-5x^2/b^2) Fb \frac{1}{EJ} dx = \left[-5/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

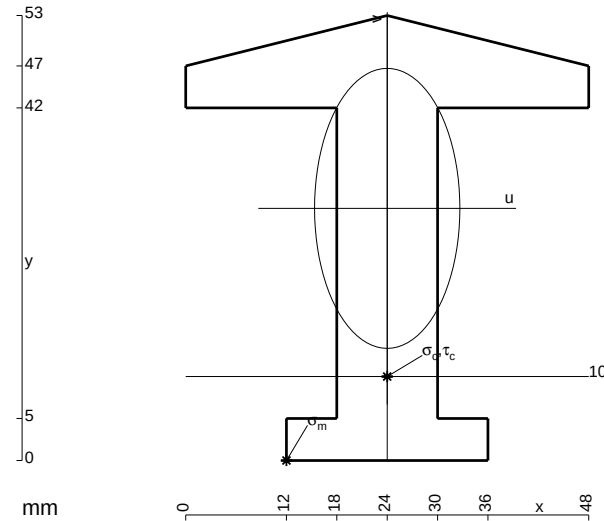
$$= (-5/3 b) Fb \frac{1}{EJ} = -5/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[-x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

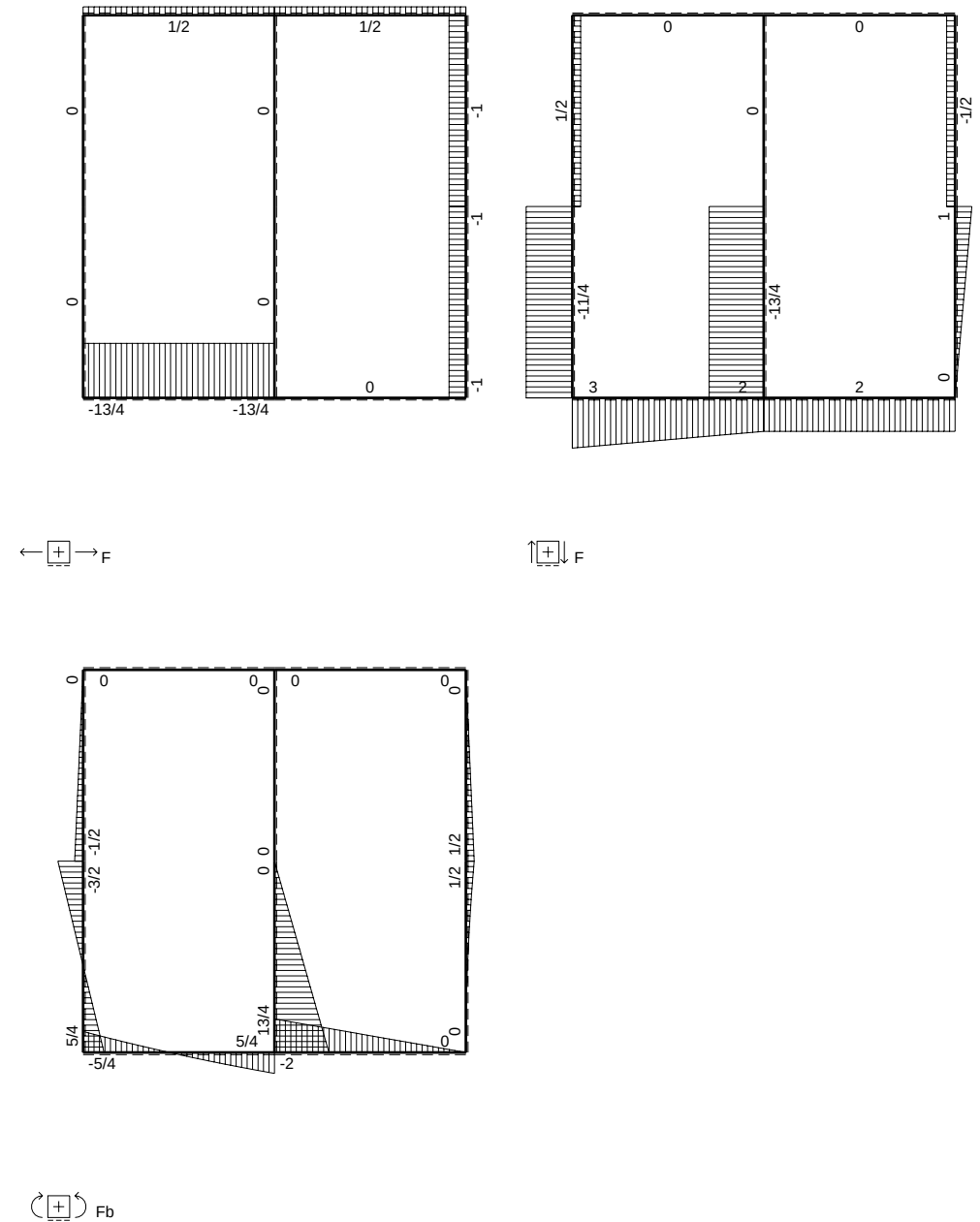
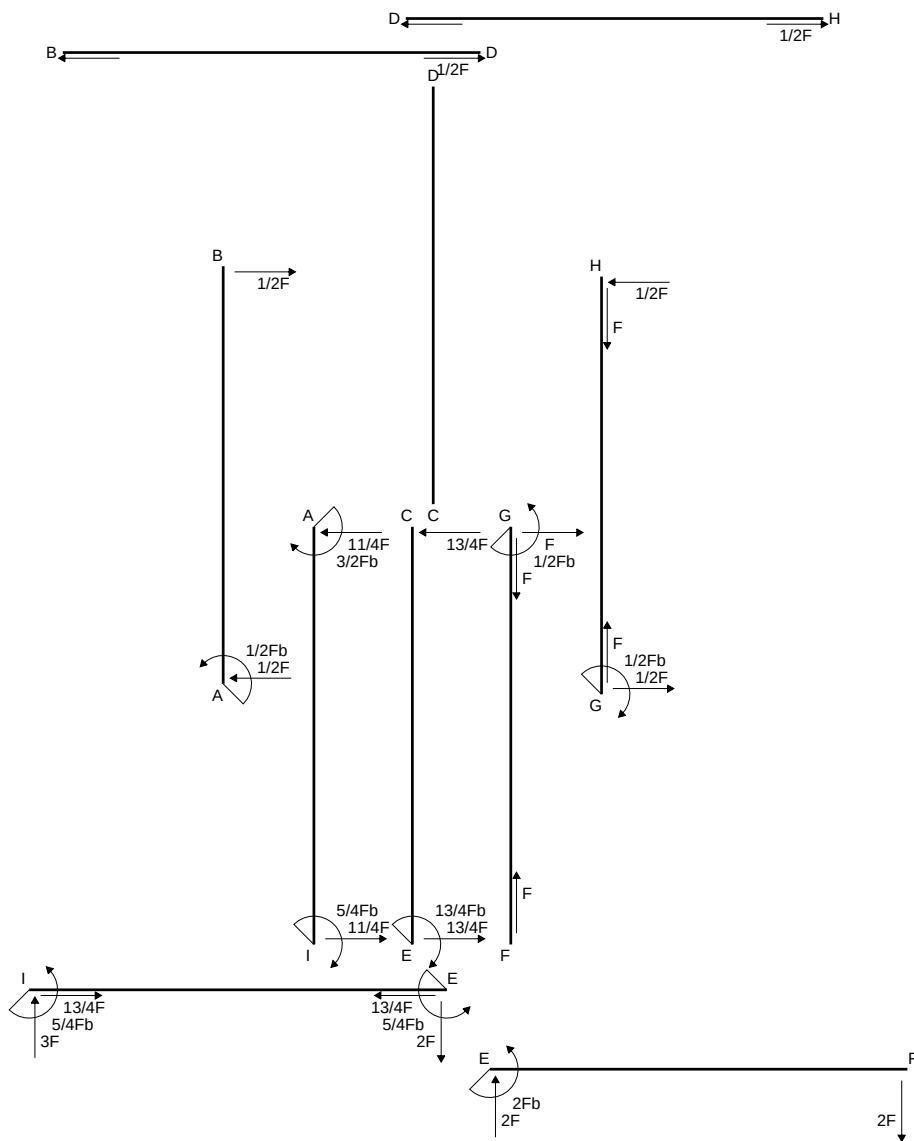
$$= (-b + 2/3 b) Fb \frac{1}{EJ} = -1/3 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-2x/b + 2x^2/b^2) Fb \frac{1}{EJ} dx = \left[-x^2/b + 2/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-b + 2/3 b) Fb \frac{1}{EJ} = -1/3 Fb^2/EJ$$



$$\begin{aligned} A &= 948. \text{ mm}^2 \\ J_u &= 263643. \text{ mm}^4 \\ J_v &= 70992. \text{ mm}^4 \\ y_g &= 30.03 \text{ mm} \\ T_y &= 3060. \text{ N} \\ M_x &= -1927800. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.03 \text{ mm} \\ \sigma_m &= -Mv/J_u = -219.6 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 10. \text{ mm} \\ v_c &= -20.03 \text{ mm} \\ \sigma_c &= -Mv/J_u = -146.5 \text{ N/mm}^2 \\ \tau_c &= 4.503 \text{ N/mm}^2 \\ \sigma_o &= \sqrt{\sigma^2 + 3\tau^2} = 146.7 \text{ N/mm}^2 \\ S &= 4656. \text{ mm}^3 \end{aligned}$$



Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_0(x)$	θ	$M_x M_0$	$M_x \theta$	$M_x M_x$	$\int M_x(M_0/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fb+1/2Fx$	0	0	0	0	0+0	0
BA b	0	$1/2Fx$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$3Fx-1/2qx^2$	$-Fb/EJ$	$-3Fx+1/2Fx^2/b$	Fb/EJ	1	$(-4/3+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-5/2Fb+2Fx+1/2qx^2$	Fb/EJ	$-5/2Fb+2Fx+1/2Fx^2/b$	Fb/EJ	1		
EC b	$-1+x/b$	$9/2Fb-9/2Fx$	0	$-9/2Fb+9Fx-9/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-3/2+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-9/2Fx$	0	$-9/2Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/4+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$3/2Fb-3/2Fx$	0	$-3/2Fx+3/2Fx^2/b$	0	x^2/b^2		
	totali						$-25/12Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$5/4Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-3x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-3/2 x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-3/2 b + 1/6 b) Fb \frac{1}{EJ} + (b) \theta = -1/3 Fb^2/EJ$$

$$L_{EI}^{xo} = \int_0^b (-5/2 + 2x/b + 1/2 x^2/b^2) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx$$

$$= \left[-5/2 x + x^2/b + 1/6 x^3/b^2 \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-5/2 b + b + 1/6 b) Fb \frac{1}{EJ} + (-b) \theta = -1/3 Fb^2/EJ$$

$$L_{EC}^{xo} = \int_0^b (-9/2 + 9x/b - 9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-9/2 x + 9/2 x^2/b - 3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-9/2 b + 9/2 b - 3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-9/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

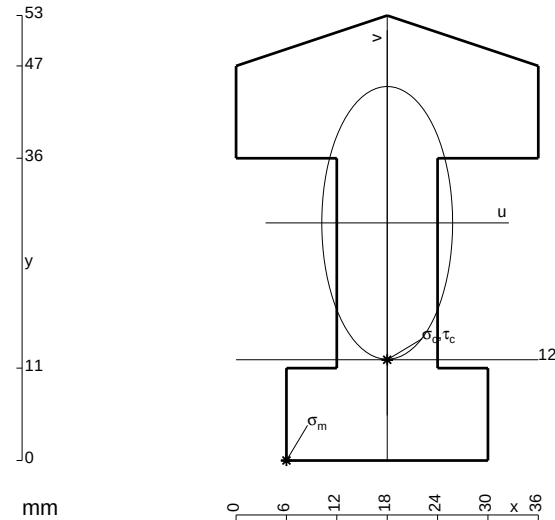
$$= (-3/2 b) Fb \frac{1}{EJ} = -3/2 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-3/2 x/b + 3/2 x^2/b^2) Fb \frac{1}{EJ} dx = \left[-3/4 x^2/b + 1/2 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-3/4 b + 1/2 b) Fb \frac{1}{EJ} = -1/4 Fb^2/EJ$$



$$A = 1068. \text{ mm}^2$$

$$J_u = 281922. \text{ mm}^4$$

$$J_v = 64872. \text{ mm}^4$$

$$y_g = 28.3 \text{ mm}$$

$$T_y = 3360. \text{ N}$$

$$M_x = -2284800. \text{ Nmm}$$

$$x_m = 6. \text{ mm}$$

$$u_m = -12. \text{ mm}$$

$$v_m = -28.3 \text{ mm}$$

$$\sigma_m = -Mv/J_u = -229.4 \text{ N/mm}^2$$

$$x_c = 18. \text{ mm}$$

$$y_c = 12. \text{ mm}$$

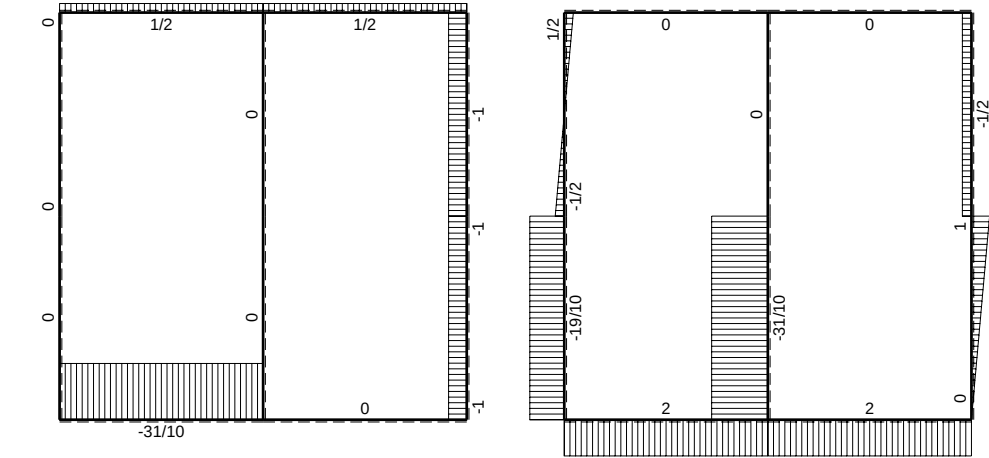
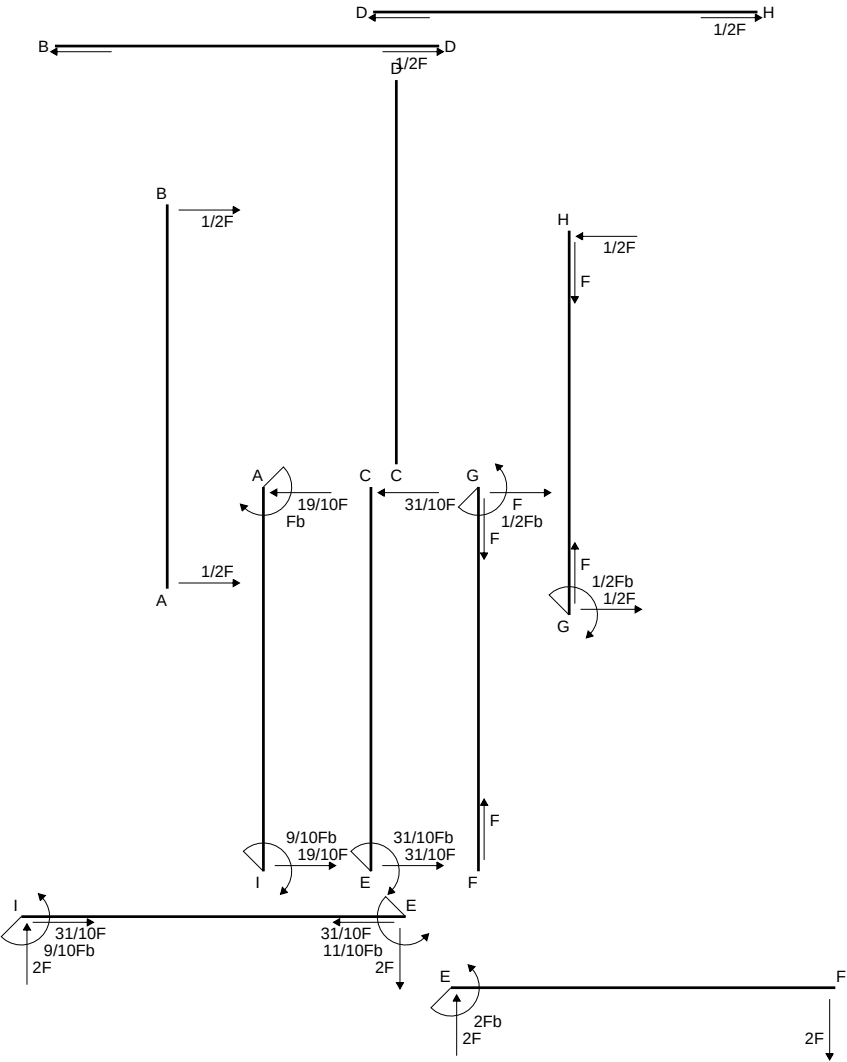
$$v_c = -16.3 \text{ mm}$$

$$\sigma_c = -Mv/J_u = -132.1 \text{ N/mm}^2$$

$$\tau_c = 6.179 \text{ N/mm}^2$$

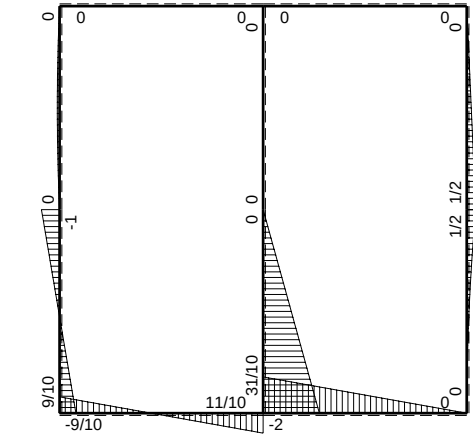
$$\sigma_0 = \sqrt{\sigma^2 + 3\tau^2} = 132.6 \text{ N/mm}^2$$

$$S = 6222. \text{ mm}^3$$

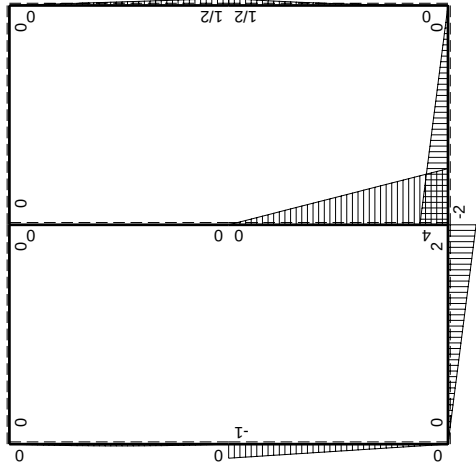
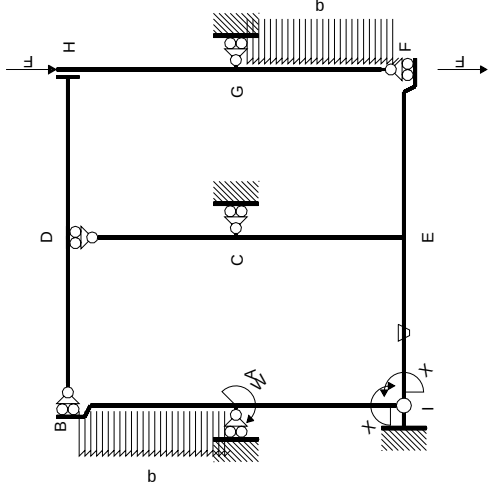


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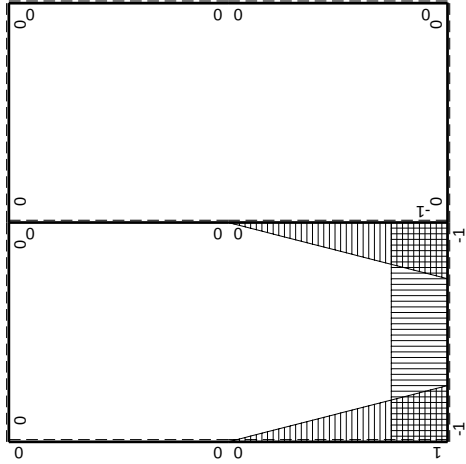


↺ $\boxed{+}$ ↻ F_b



Schema di calcolo iperstatico

M_0 flessione da carichi assegnati



M_x flessione da iperstatica $X=1$

Quadro contributi PLV per iperstatica $X=W_{IE}$

→	$M_x(x)$	$M_o(x)$	θ	$M_x M_o$	$M_x \theta$	$M_x M_x$	$\int M_x(M_o/EJ+\theta)dx$	$\int X M_x M_x/EJ dx$
AB b	0	$-1/2Fx+1/2qx^2$	0	0	0	0	0+0	0
BA b	0	$1/2Fx-1/2qx^2$	0	0	0	0		
CD b	0	0	0	0	0	0	0+0	0
DC b	0	0	0	0	0	0		
EF b	0	$-2Fb+2Fx$	0	0	0	0	0+0	0
FE b	0	$2Fx$	0	0	0	0		
FG b	0	$1/2qx^2$	0	0	0	0	0+0	0
GF b	0	$-1/2Fb+Fx-1/2qx^2$	0	0	0	0		
GH b	0	$1/2Fb-1/2Fx$	0	0	0	0	0+0	0
HG b	0	$-1/2Fx$	0	0	0	0		
HD b	0	0	0	0	0	0	0+0	0
DH b	0	0	0	0	0	0		
DB b	0	0	0	0	0	0	0+0	0
BD b	0	0	0	0	0	0		
IE b	-1	$2Fx$	$-Fb/EJ$	$-2Fx$	Fb/EJ	1	$(-1+1)Fb^2/EJ$	Xb/EJ
EI b	1	$-2Fb+2Fx$	Fb/EJ	$-2Fb+2Fx$	Fb/EJ	1		
EC b	$-1+x/b$	$4Fb-4Fx$	0	$-4Fb+8Fx-4Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-4/3+0)Fb^2/EJ$	$1/3Xb/EJ$
CE b	x/b	$-4Fx$	0	$-4Fx^2/b$	0	x^2/b^2		
IA b	$1-x/b$	$-Fx$	0	$-Fx+Fx^2/b$	0	$1-2x/b+x^2/b^2$	$(-1/6+0)Fb^2/EJ$	$1/3Xb/EJ$
AI b	$-x/b$	$Fb-Fx$	0	$-Fx+Fx^2/b$	0	x^2/b^2		
	totali						$-3/2Fb^2/EJ$	$5/3Xb/EJ$
	iperstatica $X=W_{IE}$						$9/10Fb$	

Sviluppi di calcolo iperstatica

$$L_{IE}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EI}^{xx} = \int_0^b (1) \frac{1}{EJ} dx = \left[x \right]_0^b \frac{1}{EJ}$$

$$= (b) \frac{1}{EJ} = b/EJ$$

$$L_{EC}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{CE}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IA}^{xx} = \int_0^b (1 - 2x/b + x^2/b^2) \frac{1}{EJ} dx = \left[x - x^2/b + 1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (b - b + 1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{AI}^{xx} = \int_0^b (x^2/b^2) \frac{1}{EJ} dx = \left[1/3 x^3/b^2 \right]_0^b \frac{1}{EJ}$$

$$= (1/3 b) \frac{1}{EJ} = 1/3 b/EJ$$

$$L_{IE}^{xo} = \int_0^b (-2x/b) Fb \frac{1}{EJ} dx + \int_0^b (1) \theta dx = \left[-x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[x \right]_0^b \theta$$

$$= (-b) Fb \frac{1}{EJ} + (b) \theta = 0$$

$$L_{EI}^{xo} = \int_0^b (-2 + 2x/b) Fb \frac{1}{EJ} dx + \int_0^b (-1) \theta dx = \left[-2x + x^2/b \right]_0^b Fb \frac{1}{EJ} + \left[-x \right]_0^b \theta$$

$$= (-2b + b) Fb \frac{1}{EJ} + (-b) \theta = 0$$

$$L_{EC}^{xo} = \int_0^b (-4 + 8x/b - 4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4x + 4x^2/b - 4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-4b + 4b - 4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{CE}^{xo} = \int_0^b (-4x^2/b^2) Fb \frac{1}{EJ} dx = \left[-4/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

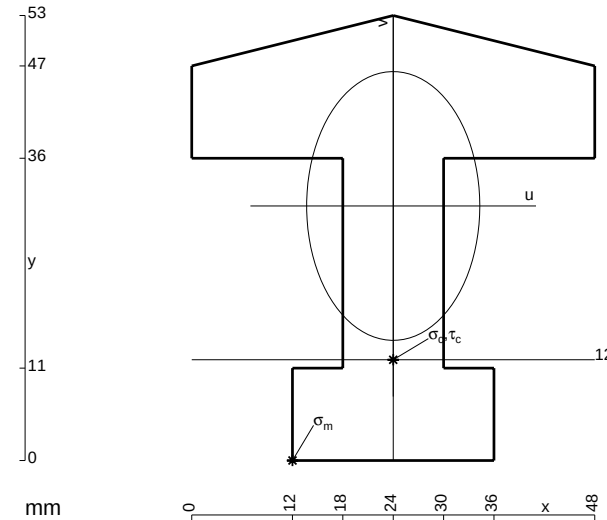
$$= (-4/3 b) Fb \frac{1}{EJ} = -4/3 Fb^2/EJ$$

$$L_{IA}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$

$$L_{AI}^{xo} = \int_0^b (-x/b + x^2/b^2) Fb \frac{1}{EJ} dx = \left[-1/2 x^2/b + 1/3 x^3/b^2 \right]_0^b Fb \frac{1}{EJ}$$

$$= (-1/2 b + 1/3 b) Fb \frac{1}{EJ} = -1/6 Fb^2/EJ$$



$$\begin{aligned} A &= 1236. \text{ mm}^2 \\ J_u &= 316729. \text{ mm}^4 \\ J_v &= 131472. \text{ mm}^4 \\ y_g &= 30.32 \text{ mm} \\ T_y &= 3380. \text{ N} \\ M_x &= -2501200. \text{ Nmm} \\ x_m &= 12. \text{ mm} \\ u_m &= -12. \text{ mm} \\ v_m &= -30.32 \text{ mm} \\ \sigma_m &= -Mv/J_u = -239.4 \text{ N/mm}^2 \\ x_c &= 24. \text{ mm} \\ y_c &= 12. \text{ mm} \\ v_c &= -18.32 \text{ mm} \\ \sigma_c &= -Mv/J_u = -144.6 \text{ N/mm}^2 \\ \tau_c &= 6.027 \text{ N/mm}^2 \\ \sigma_0 &= \sqrt{\sigma^2 + 3\tau^2} = 145. \text{ N/mm}^2 \\ S^* &= 6777. \text{ mm}^3 \end{aligned}$$